

DISCOVERY

Monthly Notebook

Scientific Manpower—
Goitre's Geography—Astro-
nomical Occasions—Radar
Techniques in Radio-Tele-
phony—DDT: Do's and
Don'ts—Peacetime Benefits
from Chemical Warfare

Biting Midges

M. A. HILL, B.Sc.

The Physics of the Sun

DAVID S. EVANS,
Ph.D., F.Inst.P.

Biology Behind Barbed Wire

L. J. AUDUS, M.A., Ph.D.

Research and Steam Raising

R. F. DAVIS,
M.Sc., M.I.Mech.E.

These Plants Saved Lives

RICHARD CLEMENTS,
B.Sc., F.L.S.

Films About Soil

Bookshelf



JULY

1946

1/6

The Measurement of Dielectric Loss—

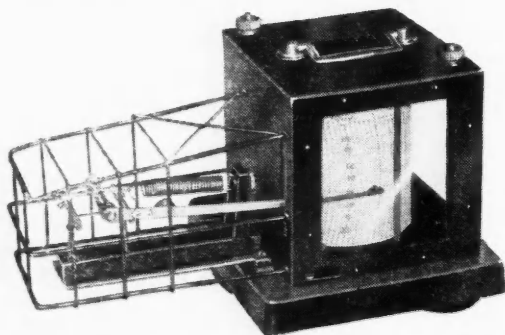
by the

METROVICK SCHERING BRIDGE EQUIPMENT



Send for full description of this portable testing equipment as given in leaflet 905/5-1.

**METROPOLITAN
Vickers**
ELECTRICAL CO. LTD.
TRAFFORD PARK ... MANCHESTER 17.



AMBIENT TEMPERATURE RECORDER

A practical necessity for controlling the heating load in industrial and other buildings



Write today for Specification RA10/36 to SUNVIC CONTROLS Ltd.
STANHOPE HOUSE, KEAN STREET, LONDON, W.C.2

Aircraft Engineering

FOUNDED 1929

The Technical and Scientific Aeronautical Monthly

EDITED BY LT.-COL. W. LOCKWOOD MARSH, O.B.E.,
F.R.Ae.S., M.S.A.E., F.I.Ae.S.

Single Copies 2s. 4d., post free.

Ordinary Subscription 26s. 0d. per annum, post free.

PRINCIPAL JULY CONTENTS

Development of the Rolls-Royce Merlin engine	
Stress Diffusion Problems—II	W. V. Goodey
Analysis of Plane Braced Frames	R. J. Cornish
Frequencies of Vibration of a Truncated Cone	H. D. Conway
Fluid Power Transmission in Aeroplanes	D. G. A. Rendell
Alloys of the Heavy Metals	G. Fitzgerald-Leslie
Servicing the Derwent Jet Engine	S. Cooper

BUNHILL PUBLICATIONS LIMITED
12 Bloomsbury Square, London, W.C.1

Scientific

BEFORE the
out suffic
were liab
had a sto
spend as
tries—bu
was the n
as an irr
purse-str

If there
view, let
the Roya
said that
larly well
at all. W
leg, but v
ability."

It has t
make uni
scientific
been conc
overcome
which is o

The re
Manpowe
Office, pri
as one of
It is frank
reports. I
trained sci
in 1955 un
makes no
believe th
serious un
the nation
gets into f
The full
double the
manpower

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

July, 1946 Vol. VII. No. 7

Editor: WILLIAM E. DICK, B.Sc.

All Editorial communications to

244 HIGH HOLBORN, W.C.1. (Tel. Chancery 6518)

All Subscriptions, Distribution, Advertisements and Business communications to
THE EMPIRE PRESS, NORWICH, ENGLAND. (Tel. Norwich 21441)

The Progress of Science

Scientific Manpower

BEFORE the war those who held that Britain did not carry out sufficient research were so far in the minority that they were liable to be laughed off the stage. The complacent had a stock reply that went like this: Certainly we do not spend as much money on research as several other countries—but look how well we do in spite of that! And such was the mood of the times that this evasion was accepted as an irrefutable argument by many who controlled the purse-strings of Science.

If there is anyone today who can find comfort in that view, let him ponder the recent words of the president of the Royal Society, Sir Robert Robinson: "Dr. Johnson said that a dog standing on one leg did not do it particularly well, but the remarkable thing was that it could do it at all. We have put up a very good performance on one leg, but we are resolved to free ourselves from this disability."

It has taken a twenty-year struggle and a world war to make universally clear the need for a great expansion of scientific activity in Britain. Now that the principle has been conceded we can begin the much harder struggle to overcome the practical difficulties, the most serious of which is our shortage of scientific manpower.

The report of the Barlow Committee on Scientific Manpower (Cmd. 6824, published by H.M. Stationery Office, price 6d.) may well be ranked by future historians as one of the key documents of the reconstruction period. It is frank and outspoken to a degree unusual in official reports. Even in stating that the prospective deficit of trained scientists is likely to be 10,000 in 1950 and 26,000 in 1955 unless drastic measures are taken, the committee makes no bones about the fact that "there is reason to believe that it represents an under-estimate (perhaps a serious under-estimate) of the number of scientists whom the nation could usefully employ once peacetime industry gets into full production."

The full implementation of the committee's proposal to double the output of science graduates cannot balance the manpower budget by 1955. And doubling the output is

about the maximum that can be reasonably envisaged in a few years.

On the necessity and possibility of doubling the output the committee stands firm. One by one it answers the arguments that have been and will be urged to show that such proposals are impracticable. It is often said, for instance, that the universities already skim off the intellectual cream and that if we increase the numbers we shall lower the standards. The report brings forward statistics to prove that of those with intelligence equal to that of the upper half of past university students only one in five has hitherto actually reached a university. There will be no lack of capable and willing students, "provided always that sufficient financial assistance is forthcoming to ensure that able students are not prevented from going to the university by lack of means". Difficulties of buildings and staff are squarely faced and shown to be not unsurmountable; practicable proposals are made for overcoming them. Finance will be of critical importance: "more than any single other factor, the universities' response to any call for expansion will depend upon a wise and generous financial policy towards them on the part of the Government." But there is no material obstacle here. Grants will have to be greatly increased, but they will still be small in terms of national finance.

The committee then passes on to consider what expansions are possible in the various universities and to comment on the proposals that these bodies have already made. Of Oxford and Cambridge: "We regret that neither of the ancient universities has found it possible to suggest any permanent expansion of its student body"; they should "regard it as a duty to make some contribution towards meeting the nation's enlarged requirements". (Here there will be controversy: expansion would inevitably change the character of Oxford and Cambridge, and there are many whose opinions deserve respect who feel that the losses consequent upon such a change might outweigh the gains.)

London, it is suggested, might be split into two or more separate universities to facilitate the organisational side of a large expansion. The English university colleges

"should aim at earning full university status at the earliest possible date". And so on through the list, each case being considered on its merits. Finally, the committee says, "there is nothing sacrosanct about the present number of universities in the kingdom. . . . Moreover, there is some reason to believe that a number of able teachers from the existing universities would welcome the opportunity of re-enacting in the twentieth century the exodus which is said to have led to the foundation of Peterhouse in the thirteenth."

Having set out its proposals (more concretely, of course, than we can indicate here) the committee then faces the fact that they will not completely solve the problem. There will still be a serious shortage for some years to come. During that period there must be a system of priorities for the use of scientific manpower, and the committee puts them, quite correctly, in the order: first, teaching and fundamental research; second, civil science, both Government and industrial; third, defence science.

The committee says little on the subject of putting these priorities into practice. By implication it rejects any system of directing scientists in peacetime. Financial attraction is the only method suggested. If salaries are to be the thing on which the allocation of scientists depends, then the Government will have to give attention to several matters which are likely to play havoc with any system of priorities designed to meet the national interest. The Government will need to check over the salary scales proposed in last year's White Paper on The Scientific Civil Service, for these proposals, which we discussed in our issue of October 1945, stood in need of revision even before they were published. The Ministry of Education is duty bound to give some attention to salary scales for secondary school teachers—that is, if it recognises the vital necessity of securing a fair proportion of science graduates for teaching. At present, as Mr. J. A. Lauwerys pointed out to a recent British Association conference, these secondary school salaries are such as to discourage a prospective teacher from undertaking a university course in science (or in any other subject). The level of salaries is going to determine not merely whether the best use can be made of the scientists who are already trained; it will also affect the number of students who will choose science as a career. The salary that will follow graduation influences the student's decision to go or not to go to a university no less than does the question of finance during undergraduate years.

So Britain now has a general strategic plan for the future production (and less clearly for the utilisation) of scientific manpower. It remains to be seen how rapidly action will be taken to implement the plan. This will require the willing co-operation of several bodies, but more than all else it will depend on vigorous leadership from the Government. Already Mr. Morrison has told Parliament that "the Government are in general agreement with the conclusions of the committee, which we recognise will involve a substantial liability on the Exchequer." The second part of the statement, taken with the recent record of the Government, encourages one to believe that finance will not be allowed to stand in the way of implementing the proposals. Not that the recent increase of the university grant from £5.65 million to £9.45 million is anything like sufficient. In spite of it a number of universities are

considering raising their fees. The grant will have to be increased rapidly to the point at which fee-raising becomes unnecessary—otherwise financial stringency will inhibit the flow of students. And thereafter it must keep pace with (or better still, for psychological reasons, keep a little ahead of) the material possibilities of expansion, measured in terms of building labour, supply of teachers and the like.

Financial arrangements to enable two instead of one out of every five potential graduates to reach the university will, of course, be of critical importance. A distant ideal is perhaps free university education for all who wish it and are fit for it; but meanwhile the ideal must be approached in practice through a wise Government policy on scholarships and maintenance grants. Again recent Government action encourages high hopes. The 360 State Scholarships awarded annually by the Ministry of Education are to be continued and the limit of £100 which has hitherto applied to the associated maintenance grants is to be removed. And further, about 1,200 winners of Open Scholarships and Exhibitions awarded by the universities will qualify for supplementation of their emoluments up to the full cost of fees and maintenance. These decisions form a useful beginning, but the numbers involved will certainly have to be increased by several thousands if the requisite doubling of the student population is to be achieved. The grants made by the Department of Scientific and Industrial Research for research students will need radical improvement—the 1945 announcement showed no appreciable advance on the pre-war situation.

Perhaps the most critical test of all will be whether or not the Government responds quickly and vigorously to the proposal to set up a new university. There are, of course, things deriving from the traditions of the older universities that are of great value to the nation, but at the same time alternative virtues of equal value could be provided by an institution free from certain negative features of those traditions. Many present teachers would welcome the opportunity of starting anew with the experience of the older universities as a guide, but with complete freedom to make whatever changes that experience suggests. In this matter will lie the crucial indication as to whether future policy is to be that of make-do and mend or that of bold pioneering.

Goitre and Geography

SIMPLE goitre is a deficiency disease resulting from lack of iodine in the diet and manifesting itself as a swelling of the thyroid. The latter is a ductless gland, the largest of the endocrines, situated just below the 'Adam's Apple' of the throat. The active secretion of the thyroid is thyroxine, a hormone which contains iodine.

In the majority of cases simple goitre has no very serious effects. It is unsightly and is often accompanied by mental sluggishness and a general lowering of vitality, but it rarely endangers life. Nevertheless it is so prevalent throughout the world as to constitute a major problem in public health. One leading authority, indeed, has stated that "simple goitre considered from the point of view of world medicine is one of the most important and widespread causes of human suffering and of physical and mental degeneracy with which society has had, and still has, to deal." In extreme cases simple goitre may interfere

with breathing and therefore causes toxic goitrous untreated

The fact that the Council enlarged twenty-f

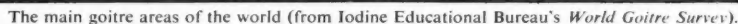
Although marked for example there is a common The accident because central A

These the population insufficiently necessary source of which the to the the drinking soil may the need drinking Very hard an indirect explains such as soil can

have to be
ng becomes
will inhibit
p pace with
eep a little
n, measured
and the like.
ead of one
ne university
distant ideal
who wish
al must be
ment policy
gain recent
ne 360 State
y of Educa-
O which has
grants is to
ers of Open
universities
ments up to

ulting from
g itself as a
ss gland, the
the 'Adam's
f the thyroid
e.

...very serious
...ed by mental
...ality, but it
...so prevalent
...r problem in
...d, has stated
...nt of view of
...nt and wide-
...physical and
...nad, and still
...may interfere



These areas represent those in which large numbers of the population are living on a diet, which provides insufficient iodine for the thyroid gland to manufacture the necessary quantity of thyroxine. The most important source of iodine in unsupplemented diets is the soil, from which the element finds its way into the body, and thus to the thyroid, by two main routes. The first is by way of the drinking water. Rain water percolating through the soil may leach out sufficient combined iodine to meet the needs of the local population. In districts where the drinking water is deficient in iodine goitre is common. Very hard waters, that is, waters rich in calcium, may be an indirect cause of goitre, as excessive calcium can interfere with the utilisation of iodine by the thyroid. This explains the prevalence of goitre in limestone districts such as those of Derbyshire and Somerset. Iodine in the soil can also find its way into the body either directly,

Recognition of the fact that simple goitre is a consequence of lack of iodine in the diet has led many countries to undertake public health measures designed to ensure that no one's diet falls below the danger level in this respect. Although some experiments have been made of adding iodine to water supplies which are deficient, much the most satisfactory method has been the introduction of iodised salt. Salt is a universally used commodity and by adding traces of potassium iodide to it—about 1 part in 20,000 is sufficient—it is possible to ensure that all members of the population obtain the necessary minimum of iodine. Iodised salt has been widely used for a number of years in the United States, Switzerland, New Zealand, and elsewhere, with excellent results. It is therefore very satisfactory to learn that after a recently completed survey the Goitre Sub-Committee of the Medical Research Council has urged the general adoption of iodised salt in Great Britain. It should, however, be remarked that several British manufacturers have supplied such salt for a number of years.

THE international links between astronomers have always been strong, and now that the war is ended efforts are being made to recreate and improve upon the pre-war international organisation of astronomy. Early in March a number of eminent astronomers representing most of the European members of the United Nations, together with the U.S.A. and the U.S.S.R., met in Copenhagen to consider the re-establishment of the International Astronomical Union. Business matters, such as the relation of

the Union to UNESCO and to the International Council of Scientific Unions were discussed, as well as the maintenance of international programmes of observation and research, but perhaps the most interesting proposal put forward at Copenhagen was that for the establishment of an international observatory. This scheme was approved in principle and will, doubtless be the subject of more detailed discussion in the future. It will be recalled that the suggestion for the establishment of research teams under the aegis of UNESCO was made in *DISCOVERY* for December 1945, the case for the establishment of an international observatory being discussed as an example of what might be done. Scientists in general will welcome proposals of this kind as moves in the direction of securing real international working co-operation, as contrasted with the mere maintenance of international scientific liaison. One of the chief functions of the proposed observatory will, it is understood, be to offer facilities for work with a large telescope to astronomers from countries which lack these opportunities.

In addition to these international arrangements the Royal Astronomical Society has taken up the question of the provision of a large telescope in Great Britain, available for use by astronomers from any of the British Observatories. Hitherto, it had been considered that climatic conditions in Britain made it impossible to use effectively a telescope of large aperture, and, to a considerable extent, astronomers here had resigned themselves to the loss of the lead in observational astronomy to the great observatories of the United States, Canada, and the Union of South Africa. The development of this attitude had important consequences not only for astronomy, but on other departments of British science as well. To take one instance alone, the lack of demand for large telescopes in Britain led to a waning of interest in large optical components on the part of the British optical industry. Lacking opportunities to apply and develop optical skill, the British industry was steadily losing ground to America, and it had become almost inevitable that orders for large or novel optical components should be placed on the other side of the Atlantic. The tacit acceptance of inferior observational equipment thus set in train a vicious spiral which tended to hold up the general development of optics in Britain.

The first step towards the arrest of this general deterioration came at the annual recent general meeting of the Royal Astronomical Society when the President, Professor H. H. Plaskett, took as the subject of his presidential address the question of the establishment of a large telescope in Great Britain. He pointed out that this country had lost the lead in observational astronomy only during the last 25 years and contended that, just because our climate was less suited to observation, the most efficient instruments were necessary to make the best use of such opportunities as were available. He put forward the view that theoretical work of real importance was carried out, in general, in places where the observations were made, so that to throw up the sponge and to resign British astronomy to purely theoretical studies would, in the end, lead to disaster for the science in Britain. Only by the establishment of a telescope with a large light-gathering power could the situation be saved. Professor Plaskett tentatively suggested a novel form of instrument consisting

of a combination of a large reflecting telescope of approximately 6-ft. aperture which could be converted to what is known as the Schmidt form of instrument, a type of telescope of very large angular aperture especially suited to the photography of extended faint objects such as nebulae and wide fields of stars.

The cost of such an instrument would be in the neighbourhood of £70,000 to £100,000. This may seem a lot of money, but it is no more than the cost of the bricks and mortar for a new physics laboratory, and a small price to pay for the rehabilitation of a department of British science, which, it is fully realised in scientific circles, can make a most striking contribution to the general development of physical science.

The suggestion of this form of instrument is a peculiarly happy one, since there are in Britain, in the persons of Dr. Burch, and his co-worker, Dr. Linfoot, both of Bristol University, optical specialists whose experience in the design of the Schmidt type of instrument is unrivalled.

The response of the meeting to the President's address was most enthusiastic and a special meeting of the Society was held in June to discuss the whole question. A number of astronomers and optical experts read papers to a packed meeting. The contribution of the Astronomer Royal (read by Dr. Atkinson) dealt with the question of climatic conditions, and showed, contrary to what had been believed, that the number of hours of night observation possible in Britain was actually considerably in excess of the number at Victoria, British Columbia, where the Dominion Astrophysical Observatory has for many years been the source of brilliant observational researches. It is, however, true that the clear skies in Britain tend to come in rather short spells, of sometimes no more than a few hours, but, as the next speaker, Professor Greaves, Astronomer Royal for Scotland, pointed out, this was all the more reason for having a telescope of sufficient size to gather enough light to permit useful exposures of faint objects to be made in these short clear spells. A smaller telescope simply wastes a short interval of clear sky since faint objects cannot be photographed in the restricted period available.

Perhaps the most striking feature of the whole proceedings was the general air of a newly awakened hope and interest in the future of British astronomy. There is a new promise of a bright future, which may, perhaps, even rival the golden age of British astrophysics—the period of the twenties and early thirties, when, using the observational material accumulated in earlier years, British astronomers such as Eddington, Jeans and Milne were able to make tremendous strides in the solution of problems of physical astronomy.

Radar Techniques applied to Radio-Telephony

THE transmission of series of short pulses of radio waves—each lasting a few microseconds at intervals of milliseconds—has become familiar through its use in radar. The technique is a fundamental feature of radar, since it was found to provide the easiest way of measuring the time of travel of the waves to the distant object and back; the shorter the pulse, the more accurate the measurement of distance that is possible. Early on it became apparent that the use of short pulses, with comparatively long

intervals
problem
feeble ec
ground n
output o
electrical
The prop
pulse wo
Another
the use
of the ra
something

Combi
replace t
radio-tele
radio wa
beam. T
and also
instead o
from the
several s
of modu

of approxi-
d to what is
type of teley-
ly suited to
h as nebulae

n the neigh-
seem a lot of
e bricks and
mall price to
ish science,
can make a
elopment of

a peculiarly
e persons of
th of Bristol
ence in the
rivalled.

ent's address
f the Society
. A number
papers to a
Astronomer
question of
that had been
observation
in excess of
where the
many years
rches. It is,
end to come
than a few
Greaves, As-
s was all the
cient size to
res of faint
. A smaller
ar sky since
ne restricted

ole proceed-
d hope and
ere is a new
s, even rival
period of the
bservational
astronomers
le to make
of physical

Telephony

radio waves
als of milli-
se in radar.
dar, since it
easuring the
ct and back;
measurement
ne apparent
atively long



An array of the 'bowl-fire' aerals used with the American Army's AN/TRC-6 set, which was brought into operational service in Europe at the end of 1944. The radio waves are concentrated in a narrow beam and require a clear unobstructed straight-line path for transmission. The set was carried on a 2½-ton truck and could be brought into operation in about two hours.

intervals of 'silence' between them, greatly helped with the problem of generating a signal of sufficient strength for the feeble echo to be detectable above the incidental background noise in the receiver. The main limit to the power output obtainable from a particular valve is the amount of electrical energy that is wasted in heating up the valve. The proportion of energy dissipated in heat is reduced in pulse working.

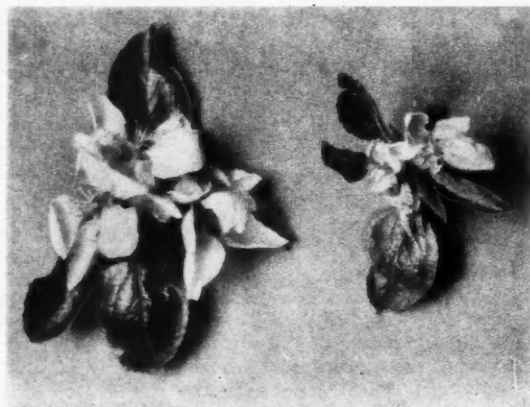
Another radar technique, and one which is favoured by the use of very short wavelengths, is the concentration of the radio signal in a very narrow beam, using reflectors something like searchlight mirrors.

Combining these two techniques, it has been possible to replace the steady broadcast carrier wave of the ordinary radio-telephony transmitter by a series of short pulses of radio waves which are sharply focused into a narrow beam. The narrow beam gives the advantage of secrecy and also saves power, while the transmission of pulses instead of a continuous carrier wave is more economical from the point of view of power used. There are then several slightly differing systems using different methods of modulating the pulsed 'carrier' with the telephonic

signal. In one system, which was used in the British Army Radio Set No. 10, the widths of the pulses are varied in accordance with the speech modulation. This No. 10 set works in the 6-7 centimetre band. The Americans, in the piece of army equipment known by the symbol 'AN/TRC-6', use pulse-time modulation; that is to say, the timing of the individual pulses in the series is varied in accordance with the telephonic signal, and the receiver is sensitive to this variation in pulse timing. A minor difference between the British and American army sets is that in the British set the aerial reflectors are normally mounted directly on top of the motor vans carrying the equipment, but the Americans reckon to mount their aerals on top of 50-ft towers. This gives a greater range of communication, but it may carry with it some slight tactical disadvantages on active service with the army.

REFERENCES

- Pulse-Width Modulation: *Wireless World*, Dec. 1945, p. 361.
- Army Set No. 10: *ibid.*, Dec. 1945, p. 383; June 1946.
- Pulse-time Modulation: *ibid.*, Feb. 1946, p. 45.
- Pulse Modulation: *ibid.*, April, 1946, p. 113.



DDT shows great promise against the apple blossom weevil. The truss of blossoms on the left is from a tree treated with DDT.

DDT: Some Do's and Don'ts

WITH an impressive record of war service to its credit, DDT is now coming into civilian use on a grand scale. With the expansion of its field of application comes a big increase in the number of DDT preparations on the market, which are being sold under a great variety of trade names.*

Already one can take a suit of clothes to the cleaners and get it impregnated with DDT against clothes moths. Miniature models of the aerosol bombs used to clear camps of insect pests are already on sale for domestic use against houseflies. But the biggest proportion of the DDT turned out by the chemical factories is bound to find its way into horticulture and agriculture. Here it is worth remembering that the first large-scale agricultural application of DDT preceded its employment against lice and the other insect pests important in medical entomology. In 1940-41, soon after its insecticidal properties had been discovered in the Basle laboratories of J. R. Geigy, S.A., by a team of chemists directed by Dr. P. Luger, DDT was used to check a plague of Colorado beetle which threatened the Swiss potato crop. In Switzerland it was accepted as effective against a number of agricultural pests before it was introduced into Britain; these pests included flea beetle, cabbage butterfly, leek moth, onion fly, raspberry beetle and cabbage root fly. But proved effectiveness against a particular pest in a particular country does not carry any guarantee that the insecticide will kill the same pest in a different country. Re-examination of the lethal power of DDT against specific insects has therefore been necessary in Britain, the United States and elsewhere. As is pointed out in the Ministry of Supply booklet entitled *Some properties and applications of DDT* (Stationery Office, 1945; 34 pp., 6d.), little work on its agricultural and horticultural applications was possible in Britain until 1944, and that is the latest year for which results of DDT field trials have been made available.

The great efficiency of DDT was rapidly realised, and so too was the possibility that it might do a great deal of

*These are a few: GNB, Santobane, Gesarol, Gesapon, Gesarex, Neocid, Neocitex, DeDeTane, DeDeTox, Anoflex, Gyron, Ixodex, Deenate,

harm, if indiscriminately used, by killing off beneficial insects along with the pests. The first warning of this danger was uttered by Dr. Luger and his co-workers in the paper in which they described their discovery of its insecticidal properties.

Honey bees were the first object of concern. The alarm and despondency which DDT has caused among British beekeepers is not without justification for their charges are certainly susceptible to DDT, and its use can therefore interfere with pollination. However, DDT should not be more dangerous in orchards than lead arsenate. But it is better to be safe than sorry, and the advice of an American scientist, J. E. Eckert, which is quoted in the new book *DDT—The Synthetic Insecticide* (by T. F. West and G. A. Campbell; London, Chapman & Hall, 1946; pp. 300, 21s.) is worth taking: *DDT should be applied only in the minimum quantities necessary to control the given pest. It should not be applied at all to plants in full bloom.*

Other beneficial insects that may suffer unless DDT is used with great care are the parasites and predators that can keep insect pests in check. According to the Ministry of Supply booklet, the parasite of the Oriental fruit moth (*Macrocentrus*) and of the codling moth are more easily killed by DDT than are the pests they parasitise. Furthermore, in areas where codling moth and red spider are found together, the extinction of the codling moth made possible by the insecticide is counterbalanced by a vast increase in the red spider population. This does not occur where the red spider population is normally very low. It is suggested that in the first case biological control by artificial introduction of insects parasitic on the codling moth seems to be preferable to the use of DDT; the reverse might be advisable in the second case. This is but one of a number of 'balance of nature' problems that the widespread application of DDT has thrown up, and these will require the close attention of entomologists if the use of DDT is to be properly controlled.

Some useful tentative conclusions are given at the end of the Ministry of Supply booklet. Firstly, it is useful against almost all insect pests of potatoes. Secondly, it will control most varieties of scale insect, leaf-eating caterpillar and thrips. Thirdly, it is effective against fruit pests, and has shown great promise against apple blossom weevil, a pest difficult to control by other insecticides; but its toxicity to bees and often useful insects demands that it be used with great care. Two further points are mentioned: DDT seems to have an adverse effect on cucurbits, such as marrows and cucumbers, and there is evidence that it stunts the growth of tomatoes and reduces their yield.

Peacetime Benefits from Chemical Defence

"How Europe will perish" and "Rain of Death" were typical chapter headings in the pre-war book that was written by arm-chair strategists who believed that poison gas would play the major and decisive role. Yet in the recent war not a single round of gas ammunition was fired by either side. If the Nazis had thought that the introduction of gas warfare would have brought victory, we can be sure that no respect for international agreement would have deterred them. They recognised that they could

never rep
was first
Civil De
very ga
organise
was now
outprod
ments ra
Ever s
on in
a great
The con
voted to
largely a
heavy bu
new kno

The
by Peter
good ex
of symp
deduced
body wa
breakdo
steps in
used by
prevent
process
was sal
combin
units are
the latte
evolved
reactive
would j
unaffected
produce
doses of
place it
proteins
enables
as an ho
peace, b
other ty
treatment
which d
tion in t

Two n
new ch
compou
analog
greater
physical
some ch
were pro
of must
of nitro
resembl
soluble
showed
vulnera
destroye
use migh
soluble

off beneficial
rning of this
co-workers in
covery of its

concern. The
caused among
ion for their
and its use can
wever, DDT
ds than lead
orry, and the
ert, which is
tic Insecticide
Chapman &
DT should be
ary to control
ll to plants in

unless DDT is
predators that
the Ministry
cal fruit moth
e more easily
ise. Further-
ed spider are
g moth made
ed by a vast
oes not occur
very low. It is
ontrol by arti-
codling moth
reverse might
out one of a
at the wide-
and these will
if the use of

en at the end
it is useful
Secondly, it
t, leaf-eating
against fruit
pple blossom
insecticides;
demands that
nts are men-
on cucurbits,
e is evidence
reduces their

Defence

"Death" were
ok that was
that poison
Yet in the
ion was fired
at the intro-
tory, we can
ement would
they could

never repeat the surprise effect that was possible when gas was first used in World War I. The General Staffs and Civil Defence authorities of all the nations had become very gas conscious, and anti-gas defence was highly organised; moreover the chemical industry of the Allies was now to be regarded with respect, being capable of outproducing Germany if challenged to a chemical armaments race.

Ever since the first world war, research had been going on in Britain, quietly in the inter-war years and on a greatly expanded scale during the recent war years. The considerable amount of research which has been devoted to chemical defence by the Allies has therefore been largely a form of insurance. The cost of the premium was heavy but a bonus will come from the application of the new knowledge gained to peacetime problems.

The development of British Anti-Lewisite (B.A.L.) by Peters, Stocken and Thompson at Oxford affords a good example of rational chemotherapy. From a study of symptoms produced by Lewisite poisoning, it was deduced that a vital stage in the utilisation of sugar by the body was being blocked. The liberation of energy by the breakdown of sugar is achieved by a complex series of steps involving enzymes, which are the biological tools used by living matter, and if one of these enzymes is prevented from functioning as it should do the whole process may go wrong. The manner in which Lewisite was sabotaging the system was recognised; it was combining with some unit groups in an enzyme—these units are known as 'mercapto groups'—and so preventing the latter from doing its job properly. The idea was then evolved by adding something else which contained more reactive mercapto groups, so that this new substance would join up with the Lewisite and leave the enzyme unaffected. Ultimately, *dimercaptopropanol* (B.A.L.) was produced which would not only protect against lethal doses of Lewisite, but would 'chase' the poison and displace it even after it had already combined with cell proteins and enzymes. This remarkable reversibility enables B.A.L. to prevent blistering even if applied as late as an hour after contamination. Lewisite is no hazard of peace, but trials have shown B.A.L. to be valuable in other types of arsenical poisoning, as, for example, in the treatment of the arsenical dermatitis and encephalitis which develop occasionally as an undesirable complication in the arsenical therapy of syphilis.

Two methods of approach are frequently used in seeking new chemical warfare agents. Either a known toxic compound may be taken as the starting-point, and then analogous or modified structures built up, in the hope that greater pharmacological activity or more advantageous physical properties may be gained, or on the other hand, some chance clue may be followed. The nitrogen-mustards were prepared by building up structures resembling that of mustard gas itself, by replacing the sulphur atom by one of nitrogen. These new substances were blister gases resembling mustard gas, but could be obtained in water-soluble forms. A study of their pathological action showed that actively multiplying cells were selectively vulnerable and that lymphoid tissue was especially readily destroyed. These two observations suggested that clinical use might be made of the nitrogen mustards in their water-soluble form for the treatment of certain diseases of



The helicopter is coming into use for the large-scale spraying and dusting of DDT and other insecticides.

lymphoid tissues, and already very favourable results have been obtained with Hodgkin's disease, and less favourable ones in certain types of cancer, such as lymphosarcoma. As only two of the nitrogen-mustard type of compounds have yet been tested out of the very large number of similar ones which have been or could be made, there is much work to be done.

Nearly all the gases used in the 1914-18 war contained some halogen atoms in their structure, usually chlorine and less frequently bromine or iodine, but none contained the related element, fluorine, although this element and many of its compounds were known to be very toxic and corrosive. Bromoacetates and iodoacetates had been used as tear gases and were known to be relatively harmless, but when the related fluoroacetates were prepared and tested at Cambridge no tear-gas effect was shown; instead they were found to be extremely toxic materials. Their use is now being investigated in the U.S.A. as rodenticides; it is estimated that one pound of sodium fluoroacetate ought to kill at least five million large wild black rats if properly administered!

The peculiar activity of the alkyl fluorophosphates (more correctly termed fluorophosphonates) was discovered by following a clue in a paper published by Lange in 1932 in a German chemical journal. He noted in passing that an odd effect was produced on his eyes while making these compounds. In 1940, Adrian and Kilby at Cambridge repeated Lange's work, and on testing the compounds a high toxicity towards animals was found, death taking place within a few minutes, whereas most toxic agents (cyanide excepted) are relatively slow in action. Later, other and more effective fluorophosphates and improved methods of making them were developed by McCombie, Saunders and their research team. A marked physiological effect in man following exposure to low concentrations is an acute constriction of the pupil and interference with vision which may last for a week. Various workers investigating the mode of action have shown the fluorophosphates to be the most effective inhibitors known of the enzyme known as choline esterase. This property, it is suggested, might find a use in medicine. Fluorophosphates might also find application as insecticides.

THE layman generally uses the word 'midges' to cover all very small gnats or flies. 'Biting midges' is a more specific term applied to the insects of the particular genus known as *Culicoides*. These are universally annoying to man since they are blood-suckers. Their 'nuisance value' may be so great that they create an economic problem; for instance, in Scotland they interfere with the tourist business, and the backwardness of crofting in western Scotland has been attributed to them. Certain species of biting midges are economically important for another reason—they can transmit diseases affecting man and his domestic animals. A repellent effective against midges has been found, but more facts about their life cycles and habits must be collected before more fundamental control measures can be taken.

Biting Midges

MARJORIE A. HILL, B.Sc.

MORE than two centuries ago, in 1713 to be precise, the Reverend Derham, then Rector of Upminster, Essex, wrote in his book, *Physico-Theology: or a demonstration of the being and attributes of God, from his Works of Creation*, as follows:

For an Instance of Insects endued with a Spear, I shall, for its peculiarity, pitch upon one of the smallest, if not the very smallest of all of the Gnat-kind, which I call *Culex minimus nigricans maculatus sanguisuga*. Among us in Essex they are called *Nidiots*, by Mouffet *Midges*. It is about $\frac{1}{10}$ of an inch, or somewhat more long with short *antennae*, plain in the female, in the male feather'd, somewhat like a Bottle-brush. It is spotted with blackish spots, especially on the wings, which extend a little beyond the Body. It comes from a little slender Eel-like Worm, of a dirty-white Colour, swimming in stagnating Waters by a wrigling Motion . . .

Its *Aurelia* (pupa) is small, with a black Head, little

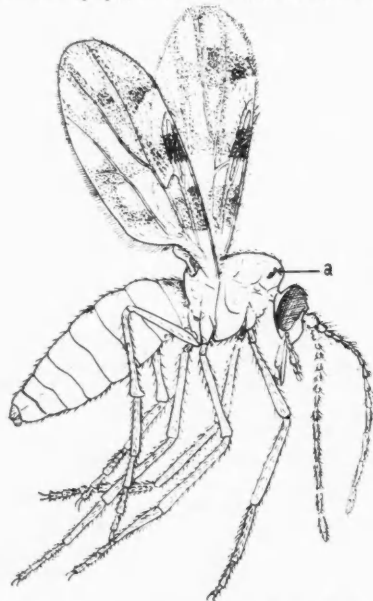


FIG. 1.—*Culicoides impunctatus*. Adult female. Wing length, 1.5 millimetres. Note the clouds on the wings and the pair of pits on the shoulders, one of which is shown (a).

short Horns, a spotted, slender rough Belly . . . It lies quietly on the top of the Water, now and then gently wagging itself this way, and that.

These Gnats are greedy Blood-suckers, and very troublesome where numerous, as they are in some places near the *Thames*, particularly in the Breach-waters that have lately befallen near us, in the Parish of Dagenham; where I found them so vexatious, that I was glad to get out of those Marshes. Yea, I have seen Horses so stung with them, that they have had drops of Blood all over their Bodies, where they were wounded by them.

I have given a figure . . . and more particular description of the gnats because, although it be common, it is nowhere taken notice of by any author I know, except Mouffet,* who, I suppose, means these gnats, which he calls midges.

The midges which proved so vexatious to the Rector of Upminster, and whose appearance and habits he so accurately describes, are probably just as numerous and irritating today as they were two hundred years ago. Although we have learned something more about their association with disease and that their bite may be dangerous as well as annoying, time has added but little to our knowledge of the life cycles and habits of the British species. This continued ignorance almost certainly explains our failure to destroy or control this noxious pest. At the time the Reverend Derham was writing his book the *Thames* valley was saturated with malaria, but its transmission by the mosquito was, of course, unknown; years of scientific study of the habits of the mosquito have led to the acquisition of knowledge of its control, and nowadays not only malaria, but also the mosquito-borne diseases of domestic stock, are almost unknown in the British Isles. Unfortunately the same extensive study has not been applied to midges and up to a few years ago there was but little that could be added to Derham's original description.

These small blood-sucking flies belong to the order Diptera, which means 'two-winged', and to the genus *Culicoides*, which is distinguished by the presence of spots or clouds on the wings and by a pair of small pits on the shoulders. (Fig. 1.) Even in the largest species the wing length is only just over two millimetres.

* Derham's reference is to Mouffet's book *Insectorum sive Minorum Animalium Theatrum* (1634) of which the original manuscript, with two dedications, is still preserved among the Sloane MSS. in the British Museum. This book is said to be the first zoological work published in England and contains a reference to small blood-sucking gnats popularly known as 'midges' in England.

DISCOV

Their curved, species w when lai laid by species. reach a l have an whitish t movement

The ha are aqua some lim fresh, flow even been trees. O matter w in damp appears t in the lat in this c northern including dung in t springs a matter. recently f edge of V (Fig. 5.) Scotland presence have given into a pu ment and the abdon Unlike th cuticle, th pupa the of the tho

The ler climatic c the egg st that of th species it

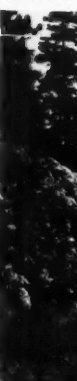


FIG. Park

Their eggs (Fig. 2) are cigar-shaped, sometimes slightly curved, may be laid singly or in echelon and, in those species which have been observed by the writer, are whitish when laid, but darken within half an hour. The number laid by individual females varies within and with the species. The larvae (Fig. 3) which hatch from the eggs reach a length of one centimetre in the larger species and have an oval, brown head, a long, smooth, segmented, whitish body, and move by a quick, wriggling, eel-like movement.

The habitat of the larvae varies with the species. Many are aquatic, some species being specific to salt waters, some limited to foul and stagnant waters, and others to fresh, flowing water. The larvae of one British species have even been found in the sap running from wounded elm trees. Other species live in soil or in decaying vegetable matter without an appreciable content of water, or even in damp rotting wood. *Culicoides obsoletus* Mg. which appears to be a universally annoying species, particularly in the late afternoon and evening in gardens and woods in this country, and indeed throughout most of the northern hemisphere, has been reared from various media including damp debris from a chestnut-tree hole, sheep dung in fields, decaying fungus, mud from the edges of springs and accumulations of dead leaves and vegetable matter. *Culicoides impunctatus* Goet. has been reared recently from marshy, but quite firm, peaty soil* at the edge of White Man's Dam, Knowsley Park, Liverpool. (Fig. 5.) This species of midge is the most prevalent one in Scotland where, it has been suggested by one writer, "its presence in conjunction with that of the kilt is said to have given rise to the highland fling." The larva changes into a pupa (Fig. 4) which is capable of very little movement and has rows of minute spines on each segment of the abdomen and a pair of small horns on the thorax. Unlike the larva, whose respiration is entirely through its cuticle, the pupa respire through these horns. From the pupa the adult fly emerges through a split along the back of the thorax.

The length of the life cycle of *Culicoides* varies with climatic conditions and with the species. The duration of the egg stage is from thirty hours to several months, and that of the larval stage also varies considerably. In some species it appears to last an entire year, while in others

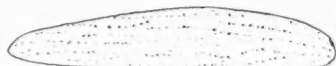


FIG. 2.—Egg of *Culicoides impunctatus*; its length is about half a millimetre. A female of this species lays 50 eggs on an average.

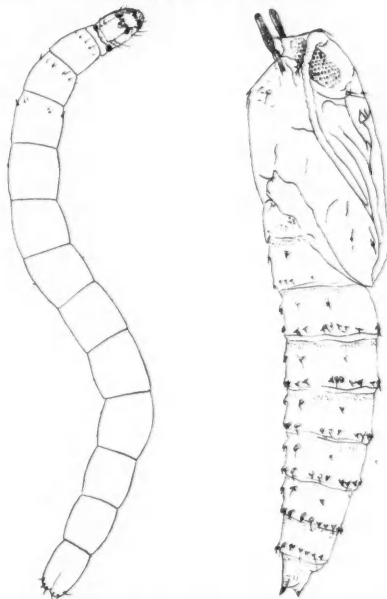


FIG. 3. (left).—Fully grown larva of *Culicoides impunctatus*; length, 6 millimetres. FIG. 4 (right). Female pupa of *Culicoides impunctatus*; length, 2 millimetres.

larval development may last only a few days. The pupal stage lasts from two to seven days, and it is thought that under natural conditions the adults survive for three weeks or a month. The Knowsley Park strain of *Culicoides impunctatus* has only one generation per year, with a peak of abundance in June, while *Culicoides obsoletus* has two generations per year, with two peaks of abundance, one in June and a second in September.

Various species of *Culicoides* are found not only in Britain but apparently all over the world except in New Zealand, Patagonia and Southern Chile. Colloquially they are known by a variety of different names; in Britain, as previously noted, as 'midges', in the United States as 'punkies' or 'sandflies', by the Indians as 'no-see-ums', and in Spanish American countries as 'jejénes'.

Wherever midges occur the annoyance and irritation caused by their bites is often so great as to constitute a major pest. They attack both birds and mammals, and according to a report from the Bahamas even lizards are not immune from their bites. One Oriental species is also reported to attack earthworms in great numbers, and another to obtain its meal of blood from gorged mosquitoes. Their numbers in some countries, including



FIG. 5.—The shore of White Man's Dam, Knowsley Park, Liverpool, showing the location of concentrations of larvae of *Culicoides impunctatus*.

* *Juncus articulatus* L. (the shining pointed rush), *Rhododendron ponticum* L. (the common rhododendron), *Polytrichum commune* L. (a moss), and *Gymnocola inflata* Dunn. (a liverwort), indicative of an acid soil, covered this area.

some parts of Britain, render outside work unbearable at certain times during the year, and they may seriously interfere with tourist trade at holiday resorts. Abroad it has been suggested that these biting insects are largely responsible for the slow development of the southern areas of the Atlantic seaboard of the United States. In Belgium it has been reported that deaths have been due to the bites of these flies, and in the British Isles the view has been expressed that in western Scotland the backward state of croft farming may, in part, be attributed to their activities. Certainly the tourist business in the Highlands of Scotland suffers severely through the activities of certain species of *Culicoides*, and in order to try to improve these conditions, the Scientific Advisory Committee of the Secretary of State for Scotland appointed a sub-committee in January, 1945, to suggest methods for the control of these aggravating insects.

Midge-borne Diseases

The chief significance of *Culicoides*, however, is as a transmitter of filariasis; in the tropics it conveys this disease, which is caused by nematodes or threadworms, both to man and his domestic stock, and in this country, although human cases are unknown, horses are infected.

The adult stage of human filarial worms occurs in the tissues of man, while the larvae or microfilariae occur in the blood, where their presence can be recognised by examining the peripheral circulation. These microfilariae are ingested by the midge with its blood meal, and undergo a cycle of development in the gut and muscles. Seven to nine days later the now infective larvae reach the mouth parts of the midge and are reinjected into a second host, man, when another blood meal is taken. In the vertebrate host the infective larvae become adult worms and discharge microfilariae which make their way to the blood stream. In 1928 it was established that *Culicoides austeni* Carter transmits the worm *Acanthocheilonema perstans* Manson, in West Africa, and that *Culicoides grahami* Austen is also a probable vector. As far as is known this particular filaria does not cause any serious pathological development in man, but it is related to the filarial worms which cause elephantiasis. A few years later, in 1933 and 1934, in St. Vincent, the complete development of the larvae of *Filaria ozzardi* Manson was observed in females of *Culicoides furens* Poey, previously fed on infected persons. This worm is a common human parasite in Central America and the West Indies.



FIG. 6.—*Culicoides nubeculosus* breeds in the liquid draining from farm-yard manure heaps.

At the same time it was shown in this country, in Herefordshire, that the filarial worm *Onchocerca cervicalis* Raillet and Henry is transmitted by *Culicoides nubeculosus* Mg., a species which breeds in the liquid running from farm-yard manure heaps (Fig. 6) and sewage, and probably by *Culicoides obsoletus* Mg. and *Culicoides parroti* Keiff. The adult stage of *Onchocerca cervicalis* occurs in the ligamentum nuchae of the horse and it has been incriminated as a cause of poll evil and fistulous withers (Fig. 7), having been found in a number of cases of these diseases. The larvae of this worm undergo a similar cycle in the midge to that of the larvae of human filarial worms. They are taken up by the insect with its blood meal and undergo a developmental cycle in the gut and muscles. (Fig. 8.) In about three weeks the larvae migrate to the mouth parts of the fly (Fig. 9) and are now infective, and ready to be injected into a second host when the midge takes another meal.

It has also been demonstrated that *Culicoides* is a vector of *Onchocerca gibsoni* Cleland and Johnston, to cattle in Malaya. These worms are usually found in nodules which occur especially on the brisket and the external surfaces of the hind limbs. In addition *Culicoides filariferus* Hoffman infected with filariae have been found in Mexico, but the identity of these immature worms has not been proved. It has been suggested that some belonged to a species of *Onchocerca* which attacks man, others to a species that parasitises equines and possibly cattle. Certain species of *Culicoides* have also been shown to be capable of transmitting filariasis of monkeys in Panama. In Formosa another species is incriminated as causing fowlpox in domestic fowls and turkeys, the midge breeding in the dung of the poultry which it attacks, while in South Africa, in 1944, *Culicoides* was proved to be a vector of the viruses causing blue tongue of sheep and horse sickness.

For many years doctors and veterinary surgeons have tried to discover some drug which would kill filarial worms in the vertebrate host, and to cure the disease. So far these researches have not been successful and control of the disease is mainly dependent on destroying the vector either in its adult or larval form. However, up to date few practical suggestions as to methods of control of *Culicoides* have been, and can be made, principally because of the gaps in our knowledge regarding the life histories and habits of these flies.

One attempt at control

The only conclusive experimental work on their control is that which has been done on those which inhabit the salt-marshes of Florida, where control has been achieved in some measure by drying of the marshes, thus rendering them unsuitable for the breeding of the flies. From the same area phenolised pine sap is reported as a promising larvicide for treatment of areas having concentrations of midge larvae.

At home certain species which are found to inhabit localised breeding-places, such as *Culicoides nubeculosus*, might be controlled by attacking their breeding-places by draining or by chemical treatment, but control of *Culicoides obsoletus* and *Culicoides impunctatus*, which appears to be the most universally annoying species in Britain, could not be achieved so easily owing to the less localised nature of the places in which they will breed. Preliminary tests with the modern insecticides gammexane and DDT

have given substantial laboratory results before the method of accurate measurement of the

Owing to the but smooth can be used while the pl backs as to be mo

For p have bee of the sk Amongst citronella

Recent Committ team of into met this wor officially *Culicoides* repellent with DN emulsion with the forestry workers has given is an emu Lanette oleic acid

country, in Here-
rca cervicalis
es nubeculosus
ng from farm-
d probably by
parroti Keiff.
occurs in the
it has been
and fistulous
mber of cases
m undergo a
vae of human
nsect with its
cycle in the
eks the larvae
and are now
nd host when

des is a vector
n, to cattle in
d in nodules
d the external
ides filariferus
nd in Mexico,
has not been
belonged to
n, others to a
cattle. Certain
be capable of
. In Formosa
g fowlpox in
eeding in the
hile in South
a vector of the
rse sickness.

surgeons have
d and kill filarial
ne disease. So
ul and control
ving the vector
up to date few
ol of *Culicoides*
because of the
histories and

in their control
which inhabit the
been achieved
thus rendering
es. From the
as a promising
concentrations

and to inhibit
es nubeculosus,
hiding-places by
control of *Culi-*
which appears
cies in Britain.
e less localised
d. Preliminary
ane and DDT



have given a promising indication of the activity of these substances against *Culicoides* larvae and adults, but further laboratory work and extensive field tests are necessary before their value in the control of this notorious pest can be accurately ascertained. Meanwhile, until some effective method of control is found we must be content with defensive measures.

Owing to the small size of the flies screening is difficult, but smudges—substances making smoke when burnt—can be used with advantage. Apparently Indian peasants while ploughing fasten smouldering cow dung to their backs as a deterrent; in Britain tobacco smoke appears to be most commonly used.

For personal protection a great variety of repellants have been suggested for application to the exposed parts of the skin, but the majority only have a transitory effect. Amongst those recommended are oil of pennyroyal, citronella, and the pyrethrins.

Recently under the auspices of the Scientific Advisory Committee of the Department of Health for Scotland, a team of biologists has made a preliminary investigation into methods of protection against midges. A report on this work is in preparation, but it has been disclosed officially that the preparation found effective against *Culicoides* contains dimethyl phthalate (DMP), the repellent used during the war against mosquitoes. Tests with DMP in a great variety of pastes, lotions and emulsions have been carried out in midge-infested districts with the co-operation of men and women engaged in forestry operations in the Highlands, other outdoor workers and hospital staffs. The preparation which so far has given the most satisfactory results as a midge repellent is an emulsion prepared according to the following formula: Lanette wax SX, 5 grammes; triethanolamine, 9 c.c.; oleic acid, 27 c.c.; dimethyl phthalate, 100 c.c.; and water.

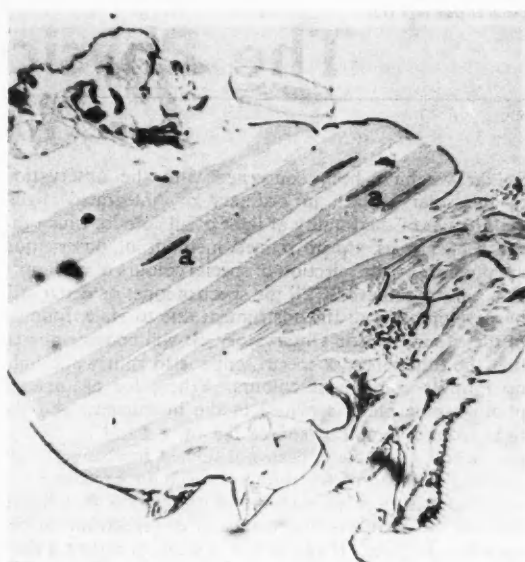


FIG. 8.—A longitudinal section through the thorax of *Culicoides nebulosus* showing two developmental forms, (a) of *Onchocerca cervicalis* in the muscles.



FIG. 9.—Head of *Culicoides nubeculosus* dissected 24 days after infection, showing (a) an infective form of *Onchocerca cervicalis* emerging; (b) antenna; (c) piercing mouth parts.

100 c.c. Smear on the exposed parts, this emulsion will ward off midges for at least two hours. It is not injurious to the skin although there may be some slight tingling when it is first applied and when washing the face afterwards. The emulsion should not be allowed to get into the eyes nor to come into contact with tortoiseshell or plastic spectacle frames.

The photographs illustrating the life history of *Onchocerca cervicalis* have been reproduced by the kind permission of Mr. J. S. Steward of Imperial Chemicals (Pharmaceuticals), Ltd.

During the past eighteen months research on the biology and control of Culicoides has been carried out at the Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3, and the author would be grateful if readers would forward any specimens they find together with a short note concerning the date, time and place of their capture, and any other details of interest.

The Physics of the Sun

DAVID S. EVANS, Ph.D., F.Inst.P.

So far we have been concerned with the observation of the solar surface in ordinary or 'integrated' light, making use of the totality of light of all colours which the sun sends to us. More refined methods of observation are possible by the selection of special colours of radiation. This can be achieved with the spectroscope, or better still by developments of this instrument due to Hale, founder of the Mount Wilson Observatory. It will be remembered that the function of a spectroscope is to split white light up into its component colours. When, for example, a photographic plate is placed in the instrument, and the light from a luminous source fed in, a band of light is produced on the plate, each position in the band corresponding to light of a definite wavelength or colour. If any colour is more abundant than its neighbours, a bright line will be seen crossing the band or 'spectrum' at the appropriate place. If any colour is weak or absent a dark line, known as an absorption line, will be produced. The lines which appear are due to the various chemical substances present in the luminous source, and each element is characterised by a system of spectrum lines which enable its presence in the source to be recognised. For example, hydrogen produces a series of lines (Fig. 9), starting with one at the red end of the spectrum, succeeding members of the series being at shorter (bluer) wavelengths, and being more and more closely spaced the shorter the wavelength. Finally a definite wavelength in the near ultra-violet is



FIG. 9.—Spectrum of hydrogen in visible region.

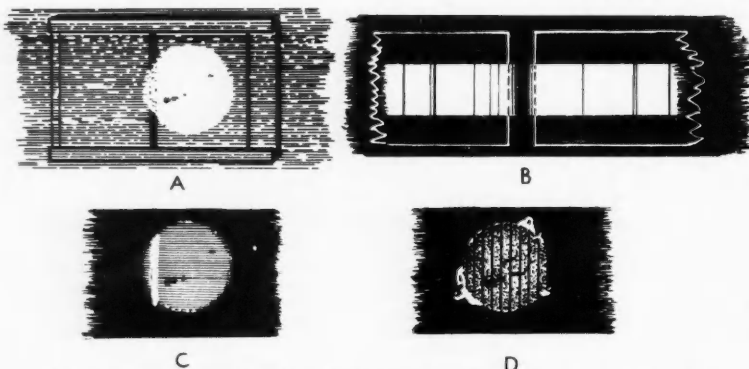


FIG. 10.—The Spectroheliograph: If an image of the sun is formed on the slit spectroscop (A), a spectrum is formed (B) showing many lines. If one of these lines is isolated by a second slit (C), the light transmitted comes from a single strip of the solar surface, and is confined to a single colour (C). If the sun's image is moved across the first slit, and the strips transmitted through the second slit and photographed side by side, an image of the whole sun, showing prominences and surface detail, can be built up (D).

reached at which the series terminates in a bunch of close packed lines. The presence in a spectrum of this series of lines is a definite indication of the presence of hydrogen in the source. In a similar way, all elements produce a characteristic spectrum by which their presence may be recognised. This is often possible even though the substance responsible for their production is present in the source in an amount of only one part in several millions. It is this extreme sensitivity of detection which has, of course, led to the wide employment in industry of spectroscopic methods of analysis; one example of its use is for the detection of minute amounts of impurities in samples of steel. (Further examples will be found in F. Twyman's article, *Spectroscopy: its application in industry*, DISCOVERY, January 1943, pp. 13-19.)

All stars show spectra, mainly in the form of dark lines on a bright background. The sun has a most complex spectrum, which it has been possible to study with great thoroughness since the unlimited light available has allowed the use of spectroscopes which spread out the spectrum to an effective length of up to several hundred feet. Something like 100,000 lines have been recognised in the solar spectrum, including those of many metals, particularly calcium, and those of non-metals such as hydrogen and helium. (Fig. 12.)

The Spectroheliograph

In order to produce a spectrum of this kind the light from part of the sun's disc is allowed to fall on a narrow slit, and the spectrum is really composed of a great many images, placed side by side, of this narrow slit. If one image is missing or feeble, there will, of course, be a dark absorption line at the appropriate place in the spectrum. What is done is to produce an image of the sun focused on the plane of the slit, so that the light which gets into the spectroscop is actually light coming from a narrow strip of the sun's surface. The spectrum therefore really consists of a number of images of a narrow strip of the solar surface arranged side by side, each image being in light of a different colour. If now a second slit is placed over the spectrum, so that, for example, only the light in one of the (not completely black) hydrogen lines, is allowed to pass through, then we have an image of a narrow strip of the solar surface in light of a single colour.

If now matters are so arranged that the first slit traverses the solar image, and if the second slit moves correspondingly, all the while keeping on the same spectrum line, then it is possible to build up, strip by strip, a complete image of the sun

entire
the sp
cation
the la
disc in

It is
single
that o
subst
hydro
of hy
calciu
which
of the

Obs
advan
the ob
bright
few oth
tion th
of the
comple
distrib
kind a
hydrog
regions
are ab

Studie

As th
round
spectro
heights
solar di
faculae
as prom
phenom
gas abo

There
position
ences: i

unch of close
of this series
e of hydrogen
nts produce a
sence may be
ough the sub-
present in the
veral millions.
which has, of
try of spectro-
f its use is for
ies in samples
F. Twyman's
y, DISCOVERY,

form of dark
most complex
udy with great
available has
pread out the
veral hundred
een recognised
many metals.
metals such as

kind the light
all on a narrow
f a great many
ow slit. If one
urse, be a dark
a the spectrum.
sun focused on
h gets into the
ly light coming
o of the sun's
rum therefore
mber of images
he solar surface
le, each image
ifferent colour.
is placed over
t, for example,
ne of the (not
hydrogen lines, is
ough, then we
narrow strip of
ight of a single

re so arranged
verses the solar
cond slit moves
the while keep-
trum line, then
ld up, strip by
age of the sun

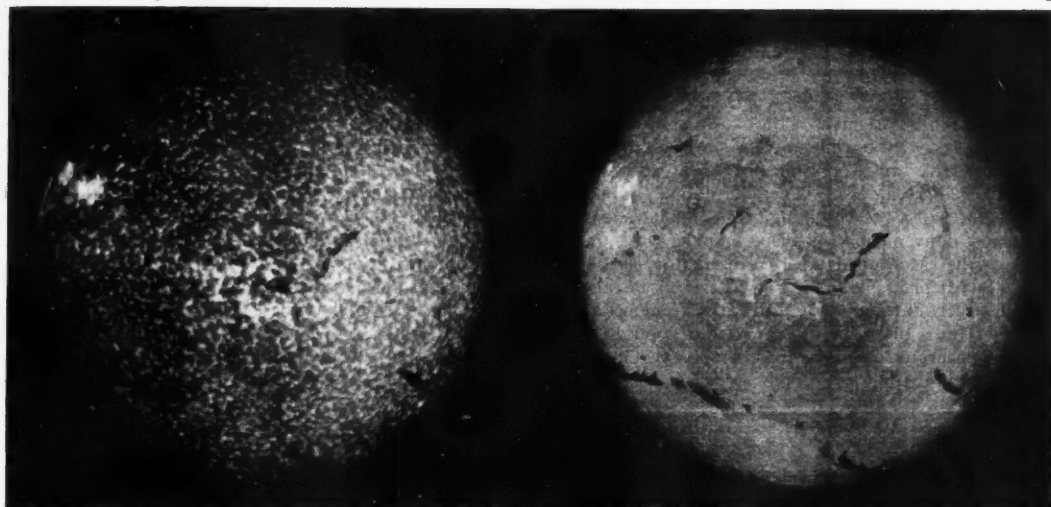


FIG. 11.—Spectroheliograms (left) in calcium light, (right) in hydrogen light. (Courtesy of Meudon Observatory.)

entirely in light of one colour. This is the principle of the spectroheliograph (Fig. 10), and, with minor modifications, of its sister instrument the spectrohelioscope, the latter showing instantaneously a small area of the sun's disc in light of a single colour.

It is perhaps more illuminating to reflect that 'light of a single colour' means, if, for example, the line selected is that of hydrogen, 'light emitted by the single chemical substance, hydrogen'. Thus a spectroheliogram taken in hydrogen light will be of value as showing the distribution of hydrogen on the sun's surface, while one taken in calcium light will show the distribution of that metal, which forms an important constituent of the outer layers of the sun. (Fig. 11.)

Observation with a device of this kind has the further advantage that it cuts out almost all stray light, and permits the observation of features of the sun which, although bright in the light of calcium or hydrogen, emit light of few other colours, so that by ordinary methods of observation they remain completely invisible. Spectroheliograms of the whole sun taken in calcium and hydrogen light have completely different appearances due to differences in distribution of these two elements, while pictures of this kind also show clearly isolated clouds of calcium or hydrogen above the solar surface, particularly in the regions of south and north of the equator where sunspots are abundant.

Studies of Prominences

As the sun rotates these clouds of gas will be carried round until, when the limb is reached, they will be seen in spectroheliograms standing above the solar surface to heights of 100,000 to 200,000 kilometres. As seen on the solar disc these clouds were given the names of *floculi* or *faculae*; as seen at the limb of the sun they are known as *prominences*, but the names all refer in reality to a single phenomenon, the existence of extensive bright clouds of gas above the solar surface.

There is a rough association between the observed positions of sunspots and the positions of solar prominences: in any detailed spectroheliogram of a spot region

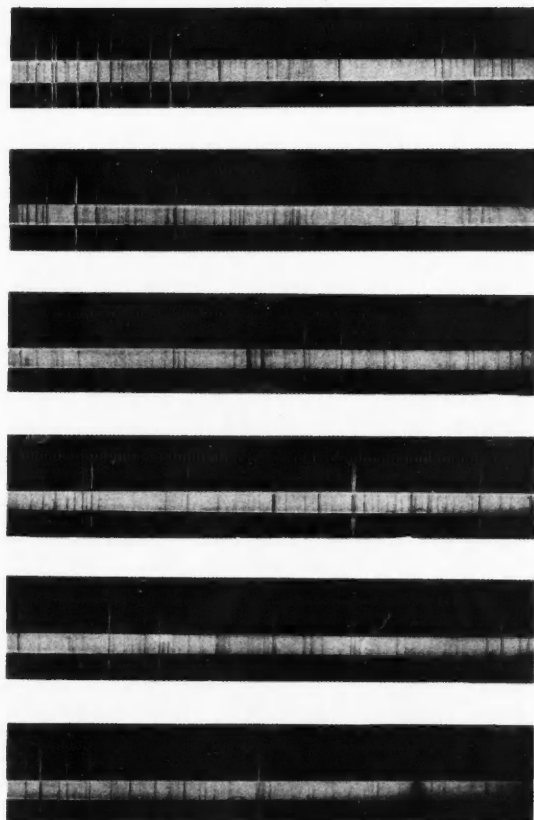


FIG. 12.—Solar spectrum from 5400A-6600A (yellow-green to red), with comparison spectrum of iron above and below. (From "The Sun", by Abetti; by courtesy of the publishers, Crosby Lockwood & Son.)

(Figs. 15 and 16), there will almost always occur a number of prominences seen in projection on the solar disc.

Although prominences have been under observation for many years, recent developments have provided an even stronger fillip to investigation of these structures. During the last ten or fifteen years two observatories particularly have made prominence observations of a quite remarkable character which have revealed unsuspected features of a breath-taking beauty and strangeness.

It is most convenient to describe first the work undertaken at the McMath-Hulbert Observatory at Lake Angelus in Michigan, U.S.A. (Fig. 21.) This institution, founded largely through the efforts of an engineer, Dr. R. R. McMath, owes its success to the application of refined engineering technique to solar observation. The ordinary spectroheliograph builds up a monochromatic image of the sun in a time of the order of a minute or two. McMath designed and built a device known as the spectroheliokinematograph, which, at speeds up to the normal rate of exposure, takes repeated spectroheliograms on successive frames of 35 mm. cinematograph film. When projected at increased speeds the changes which take place in the structure of solar prominences can be followed in detail. Their most striking feature is that, contrary to what had been thought some years ago, the majority of motions in prominences are downwards towards the solar surface instead of upwards. A great variety of forms (Fig. 13), the classification of which has engaged the attention of a veteran prominence observer, Edison Pettit, have been

recorded, of which the following description is typical of one of his prominence classes. First, over the solar surface a luminous cloud at an altitude of say 200,000 kilometres is observed. This may be fairly permanent in character and of an extent about equal to its height above the solar surface. Then, from time to time, narrow filaments of gas are to be seen emerging from the main body of the prominence and, travelling at speeds of 100 kilometres per second or even more, these stream down in curved paths to the solar surface. Often these streamers are broken into knots of gas whose shape changes as they move, and the panorama seen in moving pictures gives a vivid impression that these knots are somehow moving on fixed paths. As far as it is possible to judge, knots emerging later from the same point on the prominence pursue much the same track as knots which previously emerged from the same region. (Fig. 14.)

Researches of McMath and Lyot

As this process goes on, other changes may be taking place in the main body of the prominence. From the upper surface of the cloud a wrack of luminous gas may detach itself to whirl upwards on a spiral path, or to waver like an unsteady flame. Perhaps from the solar surface there may come an explosive ejection of material, which, hurled upwards at speeds approaching 500 to 1000 kilometres per second, shatters the main prominence cloud into torn masses which disperse as knots moving in

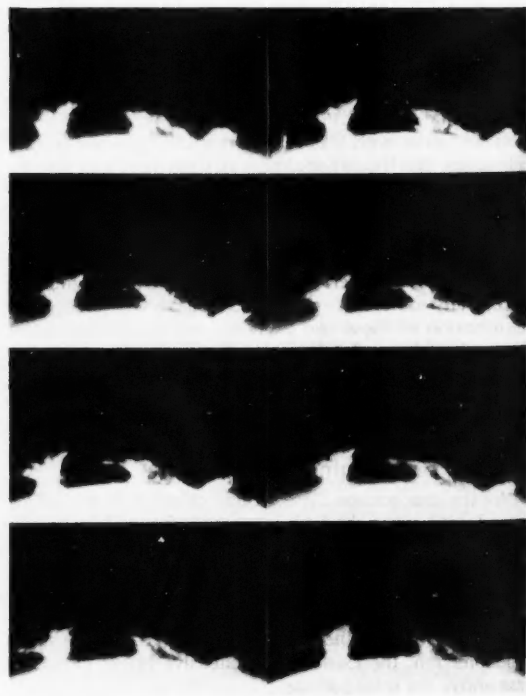
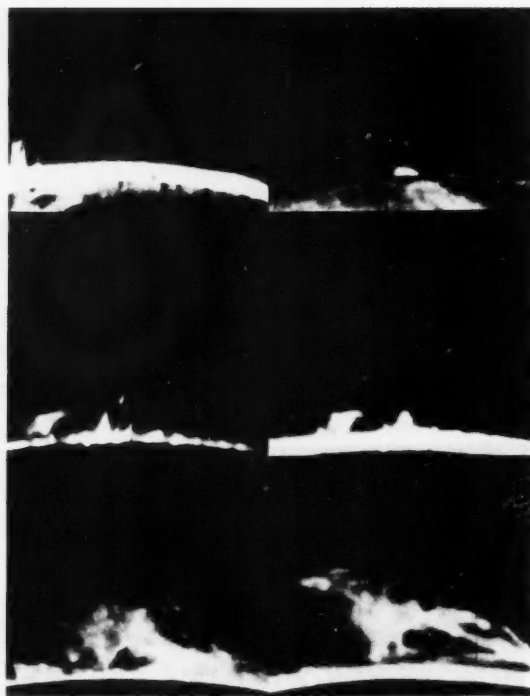


FIG. 13 (left).—Types of Solar Prominences. FIG. 14 (right).—Changes in a prominence during a period of 5½ hours. (By courtesy of Dr. R. R. McMath.)

the sa
paths.
revela
jointly
and to
pleme
differ
descri
must
these

Who
and th
a matt
observ
of gas
gress
throug
proble
of pro
empty
what
solar
terrest
genera
fact re
of the
the gr
cut of
how th
McMa
heliog
presen
lumin

is typical of the solar surface 100 kilometres in character above the solar filaments of the body of the 100 kilometres down in curved streamers are changes as they pictures gives a show moving judge, knots prominence which previously

may be taking e. From the ous gas may path, or to om the solar of material, hing 500 to n prominence ts moving in

the same mysterious way along prescribed paths. (Fig. 18.) The credit for these new revelations of prominence structure must go jointly to the McMath Hulbert Observatory and to Dr. B. Lyot, of the Pic du Midi Observatory in France, who have made complementary contributions to the subject by different methods. Lyot's work will be described presently: for the moment we must consider the problems presented by these new discoveries.

When these observations were first described and the prominence films shown, it became a matter of controversy as to whether the observed motions were in reality movements of gas, or whether they were merely the progress of regions of exceptional disturbance through a larger, invisible cloud. Other problems are presented by the mere existence of prominences: are they really gas clouds in empty space, as they appear to be, and, if so, what mechanism supports them above the solar surface? Or are they analogous to terrestrial clouds, luminous parts of a generally invisible gas? At all events the fact remains that by some means the atoms of the gases in prominences do behave as if the gravitational attraction of the sun were cut off, and it is a serious problem to explain how this state of affairs comes about. In the McMath photographs made with a spectroheliograph an additional factor of doubt presents itself. It is well known that if a luminous source is approaching the observer

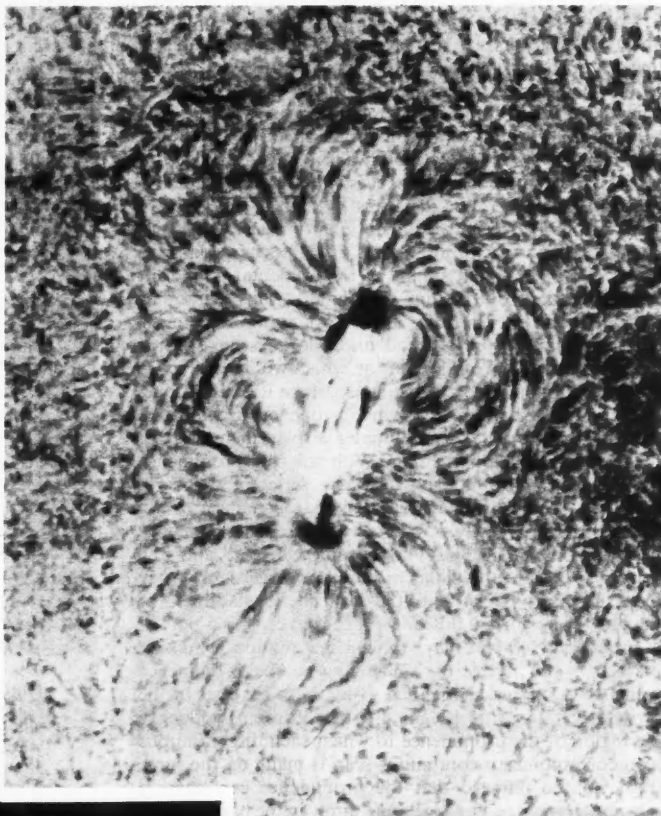
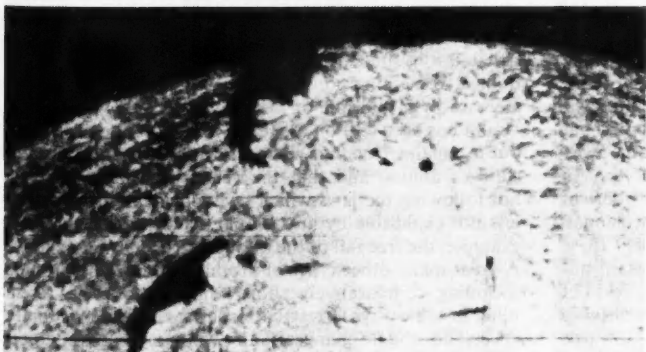
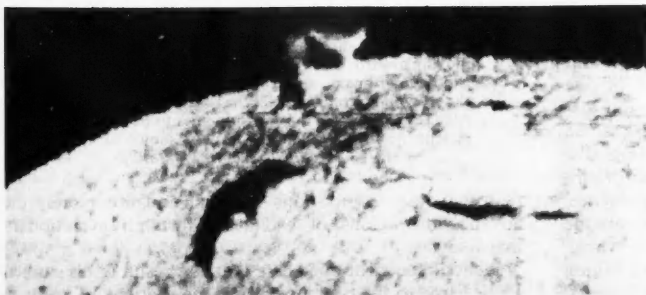


FIG. 15.—Spectroheliogram of sunspot group (hydrogen light).

FIG. 16.—Floculi appear at the sun's limb as prominences. Two spectroheliograms taken at an interval of one day.



the spectrum lines are shifted slightly, the shift being proportional to the velocity of approach. If, for example, the speed of approach is 300 kilometres per second—0.1% of the velocity of light—each spectrum wavelength will be shifted to the *blue* by an amount of 0.1% of itself. Similarly, if the velocity is one of recession there will be a shift to the *red*. Now suppose a knot of gas were stationary, then it would appear as a bright patch on a spectroheliogram; while if the same mass were suddenly set into motion towards or away from the observer at high speeds, the spectrum lines of the gas, which might be emitting nothing but hydrogen light, might be shifted so far that they would no longer be picked up by the second slit of the spectroheliograph. In this case the bright patch would suddenly disappear from the picture, not because of any annihilation of matter, but simply because of the velocity change. This shift of wavelength with velocity

is known as Doppler effect and is widely employed throughout astronomy to determine velocities of objects towards or away from the observer. In this case it may be a serious source of trouble since changes in the appearance of a prominence might conceivably be due to nothing but the results of Doppler effect.

A further difficulty which always besets this field of research is that the prominences, although presumably extending considerable distances in depth, are always seen 'in silhouette' as two-dimensional images. Apparent coincidences in structural features may thus be due not to a real coincidence, but simply to an accidental alignment of the features one behind the other. This particular difficulty seems never likely to be surmounted, but in his latest researches McMath and his colleagues have introduced new methods of observation which will largely overcome the Doppler effect difficulty and turn it to good purpose. He uses a second slit which is opened so wide that there is no possibility of a Doppler displacement shifting the spectrum line off the slit. With this the prominence is scanned discontinuously, so that a series of strips are produced, each showing the selected hydrogen line crossing the frame transversely. Where a part of a prominence has been included, the line becomes bright, and the velocity of that part of the prominence towards or away from the observer can be found from the displacement of the line off its normal position. If the slit crosses a part of a prominence where, say, a whirling motion is taking place, the bright hydrogen line due to the prominence will show a twisted shape, due to the fact that part of the prominence is approaching and part receding. To identify the region of the prominence to which each discontinuous scan corresponds, a continuous scan is made on the same frame of the film, so that the prominence can be seen dimly in the background.

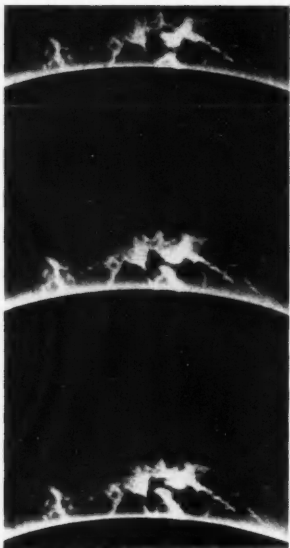


FIG. 18.—An eruptive prominence showing a tongue of gas emerging from the sun at a speed of about 700 kilometres per second. (By courtesy of Dr. B. Lyot.)

Fig. 17 shows a sequence of frames of this type and an enlarged view of one frame, showing the discontinuous strips, some of them including distorted bright lines originating in the prominence, while behind appears the prominence as a whole, showing to which region each strip corresponds.

By the use of this technique McMath has derived values for the speeds of knots of gas not only to left and right and up and down, but also towards and away from the observer. In this way he derives true 'three-dimensional' movements of these knots, an important advance in this field of investigation which goes a long way towards establishing the theory

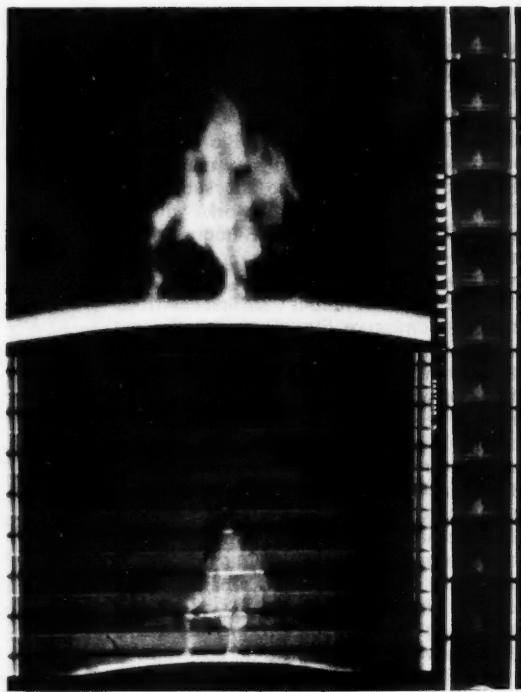


FIG. 17.—The measurement of radial velocities in prominences. The prominence shown, top left, is photographed through a spectroscope with a wide slit selecting one strong spectrum line. Eight strips are photographed side by side, as shown bottom left, where the dark lines are the images of the spectrum line in the eight strips. Where the strip includes part of a prominence, the emission spectrum of the prominence gives a bright line which is distorted if the gases are moving towards or away from the observer. An underexposed ordinary spectroheliogram superposed on the strip photograph enables the regions of the prominence responsible for the emission lines to be identified. A sequence of frames of this type is shown on right.

(By courtesy of Dr. R. R. McMath.)

that the observed motions are real and not merely the advance of regions of excitation through a stationary invisible gas.

It should be mentioned here that as a result of his studies, Pettit came to the conclusion that the motions of knots in prominences followed very peculiar laws: he considered that his observations showed that moving knots had a constant speed until, suddenly, this speed might be doubled or trebled, remaining constant again until a further sudden increase by a multiple of the original velocity took place. Doubt has been cast on the reality of these sudden changes, but it remains true that his results indicate a most peculiar state of affairs, and that the velocity changes, although not following the laws which he enunciated, are nevertheless not explicable by any simple hypothesis, such as, for example, the free fall of the knot towards the solar surface. A great many other types of prominence have been noted, including comparatively short whirling columns, resembling in some ways terrestrial tornadoes; quiescent prominences, showing no changes at all over many hours; eruptive prominences, in which material is ejected from the sun to

heights
small sp
sun and
is bewil

It wil
visible
removed
hydroge
heliogra
spectru
light so
years a
off the
using a
air wou
and ear
this wa
ing the
be said

Lyot
his stat
feet in
19, 20,
image
unusua
which

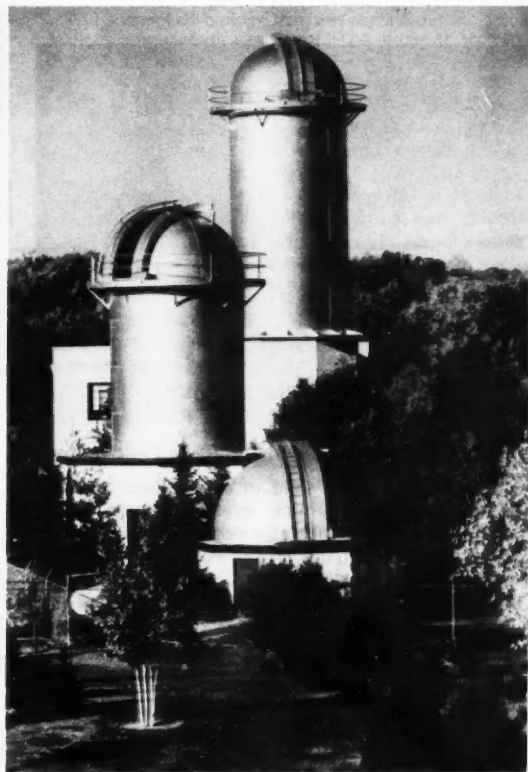


FIG. 19.—The Pic du Midi Observatory, built on a small terrace 15 metres below the summit of the mountain. FIG. 20.—Shows carriers taking the tube of a coronagraph up to the Pic du Midi Observatory; the first stage of the journey is made with mules, but at 1100 metres these have to be left behind. The ascent takes 7-10 hours. (Photographs by courtesy of Dr. Lyot.) FIG. 21.—The McMath-Hulbert Observatory.

heights of a million kilometres or more; surges, in which small spikes of gas emerge for a short distance from the sun and fall back; and many more. The variety of forms is bewildering and is almost beyond description.

It will be appreciated that in order to render prominences visible the general light from the sky and sun must be removed, leaving only the prominence light (due mainly to hydrogen, helium and sometimes calcium). In the spectroheliograph this is done simply by blocking out most of the spectrum, which cuts off most of the direct sunlight and light scattered by the atmosphere of the earth. Many years ago the possibility was considered of screening off the sun's disc so as to cut off the direct sunlight, and using an observing station at so great an altitude that the air would be very clear and the air blanket between sun and earth reduced as much as possible. It was hoped in this way that the excess light could be cut off, thus revealing the prominences and the corona, of which more will be said later.

Lyot worked for many years on this problem taking as his station an observatory at an altitude of nearly 10,000 feet in the Pyrenees—the Pic du Midi Observatory. (Figs. 19, 20.) He used a dark screen to cut out the solar disc, the image of which was formed by means of a lens of quite unusual quality, free from any scratches or blemishes which might scatter the light. Other lenses caught the light

scattered from the rim of this lens and threw it out to one side, and a further lens system formed an image of the ring of sky round the obscuring disc which covered the sun. Success came only with superhuman patience and the closest possible attention to detail. Lyot eventually succeeded in observing the prominences and the corona by manufacturing his own total eclipse at any time which he chose. Lyot's observations of prominences, which have also been combined into a motion picture film are of a quality even higher than that of the McMath observers. Although Lyot used gelatine filters to restrict the colour of light admitted to his instrument, these filters transmit so wide a range of wavelength, that, effectively, we may regard his observations as being in integrated light in comparison with the spectroheliograph observations of McMath, which employed a very narrow wavelength range indeed. Lyot's observations are therefore in one sense 'truer to life' than McMath's, but are also more restricted in the sense that the obscuring disc cuts off not only the solar disc, but also a narrow ring outside it. This meant that Lyot could not correlate his prominence observations with conditions on the solar disc beneath, nor could he observe prominences which extended only a short distance above the surface, e.g. the tornado and surge types.

However, Lyot's definition is better than McMath's and his film inspires the most casual observer with a sense of



FIG. 22.—A solar flare. (Courtesy, Meudon Observatory.)

awe and wonder at the sight of the delicate tracery of clouds revealed in the prominences. Nor is there the same difficulty with Doppler effect that occurs with the McMath pictures, although equally it was not open to Lyot to turn this to advantage in order to measure radial speeds as McMath did. It is this interplay of *pros* and *cons* which leads to the conclusion that the work of the two observers is complementary.

For a long time the spectrohelioscope was regarded as a sort of toy version of the spectroheliograph. It was felt that the amount of information which might be gained by visual observation of a small region of the solar surface was hardly likely to compare with that obtainable from a mature consideration of the photographic records provided by the spectroheliograph. During the last decade most convincing refutation of this view has come from the work of H. W. Newton of the Royal Observatory at Greenwich who has used the spectrohelioscope for a study of disturbed areas on the solar surface in the neighbourhood of sunspots, and particularly of a type of phenomenon known as a *solar flare*.

Occasionally there will be seen in the spectrohelioscope, usually in the neighbourhood of a sunspot, a small bright area (Fig. 22) which appears suddenly, and lasts usually about twenty minutes. The spectrohelioscope is provided with a device called a line shifter which allows a small alteration to be made in the wavelength admitted to the second slit. If therefore a gas cloud is rising towards the observer it can still be kept under observation by shifting the wavelength, so as to compensate for the Doppler displacement due to the upward velocity of the cloud. The line shifter is graduated directly in kilometres per second, so that the upward velocity can be measured at each moment. With this equipment it is possible to detect that, over the region of the flare, there is a cloud of hydrogen in rapid upward motion, and it may be, that, seen in profile, the appearance would be similar to that of Fig. 18 which shows three successive frames of Lyot's film, in which a tongue of gas is rising with immense speed from the solar surface. It is usually possible later on to detect, either the same cloud or another, falling back into the sun over the same region. Data on the behaviour of matter near regions in which solar flares are taking place are still being collected, and the situation is still

obscure. What is of more interest is the sequence of events described in full below, but sometimes occurring only in incomplete form which is initiated by a solar flare.

It is clear that solar flares are regions of exceptionally high temperature, corresponding perhaps to the sudden transport of exceptionally hot material from deep below the solar surface, and these regions would therefore be expected to emit a greatly enhanced intensity of ultra-violet light. This is probably the cause of the first important terrestrial effect often associated with solar flares, namely the occurrence of radio fade-outs roughly coincident in time with the visual observation of the flare, due probably to the enhanced ionisation in the upper atmosphere of the earth. Radio waves are absorbed by the more strongly ionised layer instead of being merely deflected downwards. Simultaneously with the visual observation of the flare there is usually observed a small disturbance of the earth's magnetic field, taking the form of a small kick or 'crotchet' on the magnetic traces.

It is also reasonably certain that the flare regions eject charged particles and it may happen that some time after these have left the sun the earth will encounter the particle shower. The time lag is about twenty hours, and the particles, on approaching the earth, pursue curved tracks under the influence of the earth's magnetic field. They strike the upper atmosphere of the earth most abundantly near the north and south magnetic poles, and produce electric discharges which are to be seen as aurora borealis or aurora australis. At the same time much more marked disturbances in the earth's magnetic field are observed which are known as magnetic storms.

The whole complex of phenomena is of the greatest interest, and many features still await explanation. Since solar flares are usually associated with sunspot regions, the appearance of a large spot on the sun's disc makes it probable that, when this passes the central meridian, there will be one or more solar flares, with possibly radio fade-outs, aurorae and magnetic storms in consequence. The association is by no means invariable, but it has been possible on several occasions for Mr. Newton to hazard a prediction of radio fade-outs and magnetic storms, on each occasion correctly.

One of the most recent discoveries which has been made in connexion with sunspots is that they are the source of electromagnetic waves of wavelengths intermediate between the longest infra-red radiation and ordinary short wave radio waves. The study of ultra-short waves in connection with radar during the war has, of course, stimulated work in this field. The radiation makes its appearance as background noise, superposed on the ordinary noise produced in the set by stray radiation and other causes. The change due to radiation from the sunspots is small and is apparently only just detectable, but there seems no doubt that radiation of this kind does originate in sunspots. So far no explanation has been offered, but any explanation which may be put forward is also likely to throw light on a similar nocturnal phenomenon. Radio observations at night have shown that waves of a similar kind come to us from the Milky Way, presumably being emitted by the stars.

Yet another observation which is likely to be of great significance is that the intensity of cosmic rays observed on the earth seems to be affected by solar flares.

[To be concluded]

fluence of events occurring only solar flare. of exceptionally to the sudden from deep below and therefore be nsity of ultra-first important flares, namely coincident in , due probably osphere of the more strongly ed downwards. n of the flare rbance of the f a small kick e regions eject me time after ter the particle ours, and the curved tracks ic field. They ost abundantly and produce urora borealis much more etic field are ms. f the greatest nation. Since spot regions, disc makes it eridian, there ly radio fade-quence. The t it has been on to hazard tic storms, on as been made re the source intermediate ordinary short ort waves in ns, of course, ion makes it osed on the radiation and from the sun-etectable, but is kind does ion has been put forward octurnal phe-e shown that e Milky Way, o be of great rays observed res.

[To be concluded]

This is the story of a remarkable experiment in applied biology that was carried out in Japanese prisoner-of-war camps. The success of the experiment, whereby yeast was made available for medicinal purposes, was only rendered possible by ingenious improvisation. The author was captured in Java, to which he had escaped when the Japanese overran Malaya. He had been serving with the first radar unit sent to Singapore.

Biology Behind Barbed Wire

L. J. AUDUS, M.A., Ph.D.

As a student of natural science, I frequently had a perturbing question put to me by older and less academically minded friends. It was, "What is the practical value of all the theoretical knowledge with which you load your brain?" My answer was always a vehement defence of my studies, but my argument always seemed to lack the conviction that I would have desired. In the last three years, however, as a prisoner-of-war in Japanese hands, I have had occasion to prove, to my own satisfaction at least, that pure theoretical knowledge can be of great practical value.

Even in normal everyday life the biologist has the advantage of his fellows in that he is at all times surrounded by objects and phenomena of interest to him. Particularly did this apply to the biologist in a tropical prison camp, where study of the living things around him was a refuge and an outlet from the monotony and mental strain of prison camp conditions. That advantage, however, was one to be enjoyed only by the individual, but in this article I shall deal with the application of biological knowledge to one of the most urgent of prison camp problems—the prevention and cure of vitamin deficiency diseases.

It is by now a matter of common knowledge that, of the Japanese shortcomings, by no means the least important was their failure at any time to supply prisoners with sufficient food for the maintenance of normal health. Deficiencies there were in all food constituents—carbohydrates, proteins, vitamins and mineral salts—but it was the lack of vitamins which was perhaps most universally apparent.

I start my story, then, in the Jaarmarkt camp at Sourabaya, Java, in March 1943. At this time, after a year of imprisonment on a deficient diet, the prisoners' reserves were getting low, and many deficiency diseases had appeared and were seriously on the increase. Beri-beri, manifesting itself in a variety of symptoms, such as local oedemas, anaesthesia and foot-drop, was beginning to affect no small percentage of the camp. Some treatment was afforded the worst of these sufferers in the form of occasional eggs, milk and katjang hijau (a small green pea rich in vitamin B₁ and protein) provided by purchase from the Japanese out of the meagre profits of the canteen. No vitamin preparations were at any time available.

Inadequate treatment seemed at least to stem the advance of the disease in most cases, but the most perturbing symptom, fortunately a relatively rare one at this time, remained unaffected. This was an effect on vision. This symptom, which was quite distinct from the xerophthalmia

of vitamin A deficiency, showed itself as a blurring of vision; in some cases it resulted in almost complete blindness. This was a disease quite unknown to the medical community, but the general consensus of opinion attributed it to a deficiency of one or more components of the vitamin B₂ complex. The camp Medical Officers could find nothing to arrest the disease.

Then, at the beginning of March 1943, a small draft of Dutch soldiers arrived in the camp from Malang in Central Java. They brought with them the story of an amazing cure for eye troubles discovered in their former camp at Malang. The secret was yeast. This yeast, it seemed, contained just the right vitamins to clear up the eye troubles.

Knowing that I had some pretensions to being a botanist, a senior British Medical Officer came to me to sound my reactions to the whole story. After exhaustive discussions we finally decided to attempt to produce yeast for the eye sufferers. I enlisted the help of a fellow botanist, Mr. W. Alston, a plant pathologist from Kuala Lumpur, and together we raked the rubbish tips for bottles and saucers and raided the small stocks of chemical equipment in the camp dispensary. We discovered a small room fitted with gas and electricity behind the barn-like loading shed that served us for a hospital. The camp handymen came to our aid. A bunsen burner was constructed out of scrap metal. An old hot-water cylinder, conveniently lagged, turned up as a gift from a treasured collection of domestic utensils. This was fitted with an immersion heater—Heath Robinson but very efficient—made of coiled iron wire and rapidly converted into a steam steriliser. This formed the nucleus of our laboratory.

There were two main problems which confronted us at the start. First, we needed to be able to isolate and grow in pure culture a vigorous strain of yeast. The second was the provision of a plentiful supply of a suitable medium to enable us to grow that yeast in bulk. It would be as well to mention at this point a few details concerning the nature and characteristics of yeast, so that those problems may be made clearer.

Yeast is a microscopic unicellular organism widely occurring in nature, in the air, on the surface of fruits, and so on, and having a multitude of different species and varieties.

These yeasts, like all other living creatures, require food for growth, and in the presence of suitable substances will proliferate at an amazing speed. The most important of these substances are: (1) *sugars*, particularly glucose or grape sugar, although other sugars can also be used; (2) *nitrogen-containing substances*. When yeasts find their

way into a liquid medium containing these substances a vigorous fermentation takes place. The sugars are largely converted into ethyl alcohol and carbon dioxide. It is important, however, to remember that other microscopic organisms will ferment liquids on which yeast will grow, and if the cultures of yeast are not kept pure the competition may be so severe that the growth of yeast may be completely stopped. One such a competing organism is the lactic acid bacillus which produces lactic acid, instead of alcohol, from sugar.

For the source of our yeast we chose a preparation known as 'ragi', which is used by the Javanese in a number of their fermented foods and drinks. The method of preparation of this 'ragi' was unknown to us at the time, and therefore we could not use it as a bulk source of yeast.

A small quantity of this ragi was smuggled into the camp and used to inoculate test tubes of sterilised maize malt medium. (The methods adopted for preparing this medium will shortly be described.) Vigorous growths of yeasts were obtained and from this mixed culture three strains were isolated and grown in pure culture. This isolation was made possible by the fact that the Japanese allowed the Medical Officers and Dutch army dispensers to retain some of their normal equipment, and we acquired from the camp dispensary petri dishes, pipettes, a mounted platinum wire loop and other apparatus necessary for the isolation technique. The agar-agar essential for the preparation of nutrient jelly could be brought through the canteen, since it is a normal constituent of Japanese food.

Malt from Maize

The material chosen as the source of the medium for the bulk growth of yeast was maize grain. This grain when germinated produces large quantities of diastase, an organic catalyst or enzyme which speeds the conversion of the starch reserves of the grain into sugars. Proteins of the seed also are broken down into simpler nitrogenous substances. These two groups of substances form the main food of yeast. Our problem was to experiment and discover the conditions that would give the highest yield of yeast from our limited supplies of maize. Extensive experiments were carried out over a period of a month, and such factors as the optimum germinating conditions for maximum diastase production and the optimum temperature for the conversion of starch to sugar were elucidated. These experiments involved the determination of sugars produced in the process. This was done by the quantitative use of Fehling's reagent, one of the commonest reagents of a doctor's dispensary, and used for the testing of sugars in urine. The very necessary thermometer for the temperature experiments had to be made before we could start, and for this purpose we were lucky in finding a sufficient length of glass capillary tubing and a small quantity of mercury in the dispensary. Finally the following technique was evolved for producing our medium, which we called 'maize malt wort'.

The maize was first soaked for two days in water, which was frequently changed to reduce bacterial growth. The grains were then spread in thin layers between damp sacks in zinc trays made on the camp, and were kept damp for four days. After that period the grains had produced

shoots about an inch long; this stage of germination corresponded with the period of maximum diastase content of the seedling. They were then removed from the sacks and ground into a coarse paste in a mincing machine. This paste we called 'wet malt'. The wet malt was then mixed with four times its weight of water and kept at a temperature of 55° C. for 15 hours. This was done on an electrically heated water bath, constructed from an old Dutch army field boiler, and consisting of a cubical iron tank of about 24-gallons capacity with double asbestos-lined walls and a hinged lid of the same construction. The electric heating was performed by a conduction heater consisting of two copper plates, about a half an inch apart immersed in the water of the bath and connected to the a.c. mains terminals. Current passing through the water between the plates generated about 1½ kilowatts of heat.

The problem of maintaining the bath at the correct temperature was solved by the use of a small auxiliary conduction-heater generating about 400 watts. This, working alone, was just sufficient to compensate for radiation losses from the bath, and, with the lid closed, temperatures within a degree of 55° C. could be maintained indefinitely. The 1½-kilowatt heater was therefore used only for initial boost heating. (One had, of course to make sure that all current was switched off before touching the bath, but this was a minor consideration.)

In four-gallon petrol tins, the malt-and-water mixture was immersed in the water bath, the lid closed and left from 5 p.m. till 8 a.m. the following morning. After this period about 60% of the starch in the malt had been converted into sugar, giving a sugar concentration of approximately 8%. The tins were then removed from the bath, the residue of the malt filtered through cloth and the resultant sweet solution or wort sterilised for one hour in petrol tins in the steam steriliser. After sterilisation, the tins were covered with a sterile cloth and left to cool before inoculating with the pure yeast culture.

Yeast for inoculating into this bulk medium was grown in two stages; firstly in 10 cubic centimetre test tube cultures inoculated from the previous day cultures, and secondly in 250 cubic centimetre bottle cultures inoculated with 10 cubic centimetres of a four-day-old test tube culture. The medium used in these cultures was normal wort prepared as described above *plus* 'invert sugar' to raise the sugar concentration in the solution to about 15%. Invert sugar* was prepared by boiling cane sugar with very dilute hydrochloric acid for about 15 minutes. This was used instead of cane sugar in the medium as it was much more readily fermented by the particular strain of yeast we had isolated. The bulk medium in the tins was inoculated from four-day-old bottle cultures, 20 cubic centimetres being added to each litre of wort. This was allowed to ferment for 2-3 days, after which the bulk of the yeast had settled to the bottom of the tin, together with about an equal quantity of undigested starch which had come through into the wort in the previous filtering process. The supernatant 'beer' was decanted off, and the creamy

* *Invert Sugar* is a mixture of equal parts of the simple sugars glucose and fructose. It derives its name from the change in optical activity that is involved in its preparation from cane sugar; the latter in solution is dextro-rotatory—it rotates the plane of polarisation of polarised light to the right (clockwise), whereas the solution of invert sugar is laevo-rotatory.

sludge
medica
produc
time v
250 cu
yeast.

Chan

A v
maize
with d
and the
already
It there
materi
The of
part of
from c
But ho
polish
Here a
least t
that it
organ
fermen
ism an
a fung
known

A ja
inocul
At the
be cov
tase a
55° C.
the so
the ba
Unfor
ments
author
movin
ously
few d
island
train
were,
pure
remov

On
island
rain.
const
jungle
yeast
least
bacill
both
mont
half
assoc
ticular
work
early

mination cor-
astase content
from the sacks
cing machine.
malt was then
and kept at a
as done on an
from an old
a cubical iron
uble asbestos-
construction.
duction heater
an inch apart
nnected to the
ugh the water
watts of heat.
at the correct
small auxiliary
watts. This,
mpensate for
with the lid
°C. could be
ater was there-
had, of course
before touch-
tion.)

er mixture was
and left from
er this period
een converted
pproximately
h, the residue
esultant sweet
rol tins in the
were covered
e inoculating

m was grown
tre test tube
cultures, and
es inoculated
ld test tube
was normal
ert sugar' to
about 15%.
e sugar with
minutes. This
um as it was
lar strain of
the tins was
0 cubic centi-
was allowed
of the yeast
r with about
h had come
ing process.
the creamy

simple sugars
ange in optical
sugar; the latter
polarisation of
the solution of

sludge of starch and yeast bottled and handed to the medical officers for administration to the eye patients. Our production, from 6 kilograms of dry maize grain, at this time was 500 cubic centimetres of sludge, containing 250 cubic centimetres (roughly a half a pound) of moist yeast.

Change-over to Rice

A very serious difficulty soon arose, however, because maize became scarce. The Japanese authorities could only with difficulty be persuaded to allow us to buy the maize, and then the price was beginning to strain the camp funds, already overworked in the provision of eggs and milk. It therefore became urgent that some more easily available material should be found on which to grow our yeast. The obvious thing was rice, since it constituted the major part of our diet, and even a small percentage of it stopped from our rations would supply all the material we wanted. But how could one change the starch and protein of a dead polished rice grain into a medium suitable for yeast? Here again the native *ragi* came to our aid. We knew at least that it consisted in the main of pounded rice, and that it contained a mechanism, presumably due to living organisms, which made the rice starch available for yeast fermentation. We determined to try to isolate that organism and grow it in bulk. We felt certain that it should be a fungus since certain of these organisms had long been known as a prolific source of diastase.

A jar of sterilised steamed rice was therefore taken and inoculated with a small quantity of *ragi* and left to grow. At the end of five days the whole mass of rice was found to be covered with a pink mould. It was then tested for diastase activity by covering with water and incubating at 55°C. for about 15 hours. Subsequent analysis showed the solution to contain about 5% of sugar. Here, then, was the basis of our new method of using rice for yeast growth. Unfortunately, on the very day that these initial experiments were concluded, instructions came from the Japanese authorities that the camp was to be split up and would be moving elsewhere. Our laboratory and our gear, so laboriously collected, all had to be abandoned, and within a few days I found myself on a transport ship bound for the island of Haroekoe in the Moluccas, and Mr. Alston in a train carrying the sick and aged to Bandoeng. We were, however, both fortunate in being able to secrete pure cultures of our yeast in our kit, and these were not removed in the kit inspection prior to our departure.

On the evening of May 5, 1943, I was landed on the island of Haroekoe in pitch darkness and in torrential rain. We found ourselves being herded into partially constructed palm and bamboo huts in roughly cleared jungle, and it seemed to me that all hopes of continuing yeast production had gone. Within the next month at least half of the camp of over 2,000 was down with bacillary dysentery. Food was much worse than in Java, both in quantity and quality, and during the following few months 20% of the men in the camp died and well over half the remainder were incapacitated with beri-beri and associated deficiency diseases. Pellagra became rife, particularly in the fitter section of the camp which was working on the airfield. I myself fell a victim to dysentery early in May, but by the end of September recovered

sufficiently to do odd jobs about the camp, although my own eyes had become seriously affected.

About this time close on 1000 Dutch prisoners finished the building of an air strip on the neighbouring island of Ceram, and were brought into the Haroekoe camp to swell our working parties so seriously depleted by disease. Whilst on Ceram one of their number, a plant pathologist, had been making small quantities of yeast. Early on, maize had been available on Ceram, and the process he used had been very similar to the one we had evolved in Sourabaya. When he arrived on Haroekoe, however, the maize supply had long since been exhausted, and he had been reduced to the making of a very poor quality of yeast by the fermentation of a mixture of rice washings, cane sugar and germinating coconut water. Rice washings were obtained from the cookhouse, and contained, in addition to small quantities of vitamin B₁ from the polishings still adhering to the grain, small quantities of a fermentable substance.

100 cubic centimetres of this fermented liquid was given to each man per day while on Ceram, and the general health of these men was much better than ours. Soon after the Dutchman's arrival, we discussed the whole matter, and decided to start again with experiments left off in Sourabaya.

Certain improvements were immediately put into force. The use of invert sugar was introduced in place of cane sugar. Fortunately for the preparation of this invert sugar some small quantity of concentrated hydrochloric acid was obtained from a medical officer's kit. This improved the yield of yeast, and also led to a significant drop in the lactic acid bacteria that had been the scourge of yeast-making in the poor medium on Ceram. For checks on yeast growth we used a microscope, and counted cells by means of a haemocytometer (the instrument used for counting blood corpuscles.) The latter was also borrowed from a Medical Officer's kit. Fortunately my colleague's eyes were still in fair condition, and he was able to make these observations. The second improvement came by adding to the medium a hot extract of all the overripe and damaged bananas from our small canteen. The sugars in the extract enriched the medium considerably. Further attempts were made to obtain maize, but these proved fruitless. Finally we concentrated on the isolation of a pure yeast strain (my Sourabaya culture had been lost en route to Haroekoe), but owing to the lack of such materials as cotton wool, test tubes and agar-agar, we met with little success. By the use of a steam steriliser, constructed out of a four-gallon petrol tin, bottles and bottle media for the inoculant were sterilised, and this still further reduced the lactic acid content of the final product and increased the yeast yield.

Yeast concentrations, however, were still far below those of Sourabaya, and most attention was devoted to the isolation of a fungus rich in diastase, which could be used to break down the starch of the rice grain into sugars for fermentation. The first experiments consisted of exposing a bowl of steamed rice to the air for about 15 minutes, and then covering it over with a damp cloth and leaving it to stand for two or three days. After this period many moulds were found to be growing on the surface, the most important of which were the following:

(1) *Rhizopus oryzae*. This produces a web of white



Top—The two men on the left are engaged in sterilising medium for the bottle cultures. The man on the right is busy crumbling up the mats of rice after the completion of fungus growth. The full and empty trays can be seen on his left and right respectively. The leaves which have been used for covering the rice are in the foreground.

Centre—On the right the crumbled rice mats from the trays are being pounded up with water prior to digestion at 60°C. The other two men are engaged in sterilising the digested rice in large iron dishes as a prelude to fermentation.

Bottom—The two central figures are placing the hot mush of rice, fungus and water at 60°C. in a 'hot-box' to be left for 24 hours to digest, during which process the starch is converted into sugar. The man on the left is pounding up dried rice mats in a wooden mortar to serve as the inoculant for subsequent trays.

threads which later became covered with innumerable minute black specks, the spore-bearing bodies. This fungus was invariably the first to appear and was the most prolific grower.

(2) *Aspergillus wentii*. This first produces white threads which rapidly turn canary yellow, staining the rice grains yellow at the same time. This subsequently becomes covered with a mass of chocolate-brown spores.

These two mould fungi are well known in Java, as they are the causal organisms in the preparation by fermentation of certain native foods, principally 'tempeh kedeleh' from the soya bean. As we discovered later, on our return to Java, *Rhizopus oryzae* is also the principal organism of the 'ragi' previously mentioned, and is the chief agent in the breakdown of starch in that preparation.

Owing to its known use in the making of 'tempeh kedeleh' and to the fact that it was the most prolific grower, *Rhizopus oryzae* was chosen for our experiments. A pure culture of this fungus was grown on sterile steamed rice in a jam-jar, after isolation from the culture in the bowl. This fully grown pure culture was subjected to a similar digestive treatment as applied to the pink fungus isolated in Sourabaya. Our initial tests showed a yield of 5-8% reducing sugar, and subsequent experiments gave yields of yeast equal to those obtained on the maize malt in Sourabaya. With these gratifying discoveries behind us, we proceeded with more intensive experiments on methods of bulk production, and in the course of three weeks to a month, the following technique was evolved.

Hot steamed rice was taken fresh from the steamers in the cookhouse and spread out on clean sacks to cool. After cooling it was again spread out in layers about half an inch thick on special wooden trays constructed in the camp. These trays were about three feet long, two feet wide and three inches deep and had a sacking bottom supported by wooden laths. The bottom of the tray was first covered with large clean leaves picked freshly from trees growing plentifully on the camp, and these leaves were sprinkled with grey powder produced by pounding the dried pure culture of the fungus in a wooden mortar. The half-inch layer of rice was then spread on top and sprinkled again with the culture powder and again covered with leaves. These leaves served to keep the whole mass suitably moist during the subsequent germination and growth of the fungus. The daily production involved on the average twelve of these trays, which were stacked in a pile in a warm corner of the hut and left for 24 hours. At the end of this period the mass had become considerably warmer than the surrounding air (about 10 to 15°C.) as a result of the active fungal growth, and the threads of the fungus could be seen filling the spaces between the rice grains. The leaves were now removed from the top of the trays and the trays spread out to cool. After a further 14-16 hours of growth the rice grains were completely enveloped in a solid mass of fungal threads, and the whole mass could be lifted out in one piece, looking very much like a thick woollen blanket. These rice mats were then crumbled up into small pieces and mashed up to a sticky paste with a small quantity of water. This was then poured into sterilised earthenware carboys of about 25 litres capacity. (These had originally come into the camp containing locally made ketchup bought from

the nation
careful
present
Sterilise
which v
consiste
After w
22 hour
ture ha
remove
through
hyphae
sweet m
tions s
growth
obtaine
heated
covered
the year
The
steps.
consist
bring s
medium
pith o
bambo
petrol-
with a
batch.
our o
The se
ware o
These
cultur
rice di
48 ho
of the
cooled
each
and e
amou
daily
of mo
ration
The
vario
actual
work
very
The
diffic
stay
troul
final
pure
faile
to be
that
of th
W
that

an innumerable bodies. This and was the white threads the rice grains ntly becomes res. own in Java, preparation by pally 'tempeh' erer later, on the principal d, and is the that prepara- g of 'tempeh' most prolific experiments, sterile steamed culture in the subjected to a pink fungus ed a yield of riments gave e maize malt eries behind eriments on urse of three s evolved. e steamers in cks to cool. s about half ucted in the ng, two feet ing bottom he tray was reshly from e leaves were ounding the len mortar. on top and ain covered whole mass nation and nvolved on tacked in a r 24 hours. e consider- 0 to 15° C.) threads of en the rice top of the r further completely s, and the oking very rice mats d mashed of water. carboys of come into ight from

the natives.) Hot water was now added slowly and with careful stirring until there was twice as much water present as rice and the temperature had risen to 60° C. Sterilised wooden stoppers were now put into the carboys, which were immediately deposited in 'hot-boxes'. These consisted of empty tea chests lined with layers of sacks. After well covering with more sacks, they were left for 22 hours to digest. At the end of this period the temperature had fallen to about 40° C. The carboys were then removed from the 'hot-boxes' and the contents strained through mosquito gauze. This removed all the fungal hyphae and undigested portions of rice grain, and left a sweet milky liquid, containing about 8% of sugar. Estimations showed that, under the best conditions of fungal growth, up to 90% conversion of the starch into sugar was obtained in this way. The filtrate was subsequently heated to 70° C. and allowed to cool in large iron drums covered with sterile cloth before being inoculated with the yeast.

The inoculation procedure was performed in three steps. Firstly bottle cultures were made on a medium consisting of the rice digest with invert sugar added to bring sugar concentrations up to 15%. These bottles of medium were fitted with porous bungs made from the pith of the sago palm leaf-stalk and provided with bamboo caps to keep dust out. They were sterilised in the petrol-tin steriliser over a wood fire before inoculating with a heavy and active three-day culture from a previous batch. This heavy inoculation on a strong medium was our only method of keeping cultures reasonably pure. The second stage of fermentation was in sterile earthenware carboys containing 7-8 litres of sterilised rice digest. These were inoculated with $\frac{1}{2}$ -1 litre of a three-day bottle culture and allowed to ferment for 24 hours. This 24-hour culture then served as the inoculant of the 50-100 litres of rice digest in the iron drums. The final fermentation lasted 48 hours, a period necessary for the complete exhaustion of the sugar. This fermented liquid was sterilised at 70° C., cooled, and issued in 50 cubic centimetre portions to each man on the camp. Sufferers from chronic pellagra and eye troubles received approximately three times this amount. This dosage corresponded with a calculated daily production of approximately 2.0 kilograms (4.5 lbs.) of moist yeast and required about 1.5% of the daily rice ration.

The cartoons reproduced on the opposite page show various stages in this process; they were sketched from actual scenes in the yeast 'factory' on Haroekoe, and the workers portrayed here are drawn as caricatures of the very mixed bag of helpers that made the project a success.

Things did not always run smoothly, however, and many difficulties were encountered during the remainder of our stay in Haroekoe. In the initial stages of the process much trouble was still being had with lactic acid bacteria in the final fermentation stage. Further attempts at isolating a pure yeast culture for inoculation of the bottle medium failed, although in these bottle cultures the ratio of yeast to bacterium was never less than 100 to 1. It was obvious that conditions in this bulk medium favoured the growth of the bacterium at the expense of the yeast.

What might these conditions be? It was then realised that we were inoculating the bulk digest while it was still at

temperatures of about 35° C., since it had not had sufficient time to cool to air temperature after sterilisation. Could this possibly be the cause? To test the possibility the drum containing the hot digest was immersed, immediately after sterilisation, in the river, which flowed past the end of the cookhouse, and the temperature dropped in two or three hours to 24-25° C. The results were most gratifying. Lactic acid content dropped and the yeast content rose proportionately, and finally, after this method had been working for a week or so, lactic acid disappeared almost entirely from the drums. Later we verified that the optimum temperature for yeast is about 25° C., whereas for the lactic acid bacterium it is much higher.

The second difficulty arose owing to the failure of our small stock of hydrochloric acid and the inability to prepare invert sugar. This tended to jeopardise the production of sugar-rich medium, and so to reduce the purity of the bottle cultures. A way out of the difficulty was provided by the lactic acid bacterium. When rice digest was allowed to stand and become spontaneously infected with this bacterium from the air, the concentration of lactic acid after a few days was found to be about 1.5%.* Experiments showed that this lactic acid could be used in place of hydrochloric, and thenceforward cane sugar was inverted by keeping a 50% solution in the lactic acid medium in a rice steamer at 100° C. for 4-5 hours. In this period complete inversion was obtained.

The whole process was eventually brought back to Java by the survivors of the Amboina working drafts, and yeast continued to be made in the Batavia and Bandoeng camps. In the 'Cycle' camp in Batavia a slightly modified process was adopted for the manufacture of a baker's yeast, and was used in bread-making for the remainder of our time in captivity.

The question naturally arises as to what value this yeast was in the provision of essential vitamins. In Sourabaya, where it was the intention to supply the eye sufferers only, the ration of yeast per man should have been sufficient to satisfy all deficiencies in the B₁ and B₂ complex. Whether this would have had any curative effect on eyes cannot be said, as we were only in full production for about a week. In Haroekoe deficiencies were so much worse than in Java that here it was a question of providing every man with the maximum amount possible. This amounted in the best periods to a calculated quantity of 1 gram of fresh yeast per man per day, the eye patients getting about 3 grams. These small doses had no conclusive effects on chronic beri-beri and eye troubles, although many sufferers claimed that their eyes improved in the latter months. I myself was such a case. Pellagra, however, which had been serious and widespread at the beginning cleared up completely in the first three months of the yeast distribution, although the quality of the food tended to deteriorate rather than improve over that period. In view of this fact, it seems likely that the small but constant daily rations played a very important part in maintaining the general health of the camp, and in keeping the reasonably healthy individuals above the threshold at which symptoms of vitamin deficiency become apparent.

* This determination was made by neutralising with soda solution of known concentration, using an indicator dye obtained from the skin of a local cherry-like fruit, *Flacourtia* sp.

Research and Steam Raising

R. F. DAVIS, M.Sc., M.I.Mech.E.

CORRECT treatment of the feedwater is also important. A scale deposit of one thirty-second of an inch thick on the inside of a tube is considered far too much for satisfactory operation, since it may cause a radiantly heated boiler tube to overheat, swell and eventually burst. A burst tube in a high pressure boiler is not usually attended by any unhappy physical consequences to the operating staff, because all the pressure parts are encased. But if a burst occurs during a period of peak load a large area of electricity supply may be temporarily deprived of light and power. Such accidents, combined with a dearth of reserve capacity, have occasionally caused widespread breakdowns in electricity supply during the last two winters.

The pure scientist has perhaps contributed more in the field of water treatment towards the satisfactory functioning of boilers operating at high pressures than in any other direction. The study of the behaviour of salts in solution at high temperatures and pressures is essentially the domain of the physical chemist. It is now known that the equilibrium of the various salts in boiler water, which varies with temperature, pressure, concentration, and pH value of the solution* is vitally important from the point of view of preventing scale formation, corrosion and embrittlement of the metal, and the carry-over of salts in the steam.

All natural waters contain salts in solution, principally calcium and magnesium salts, and these, together with other impurities, must either be eliminated, or so altered in constitution, that they do not form a hard scale. Scale elimination by the utilisation of the cheap chemical soda-ash (anhydrous washing soda), used at pressures below 200 lb. per sq. in. proved unsatisfactory at higher pressures, failing to react with the calcium and magnesium salts as intended. Further research here led to the substitution of various phosphates, for example sodium tri-phosphate, as either preliminary softeners, or as conditioners fed directly into the boiler drum.

Research has also provided suitable synthetic mineral zeolites† for the pre-treatment of feedwater, and more recently organolites. The latter compounds were discovered about 1935 when two chemists (Adams and Holmes) were investigating the properties of certain synthetic resins.

Within the last year or so the commercial applications of this research have enabled the purification of raw water to be carried out at a cost below that of distillation. Two kinds of organolites are employed, one removing the basic radicals and the other the acidic.

As a result of all these developments in water treatment and the routine testing of water by competent chemists, internal scale in high-pressure boilers is a rarity. Modern operating technique demanding scale-free tubes exposes

the metal, however, to the dangers of corrosion by oxygen dissolved in the water. Initially the oxygen is removed by a mechanical de-aerator, which heats the water slightly and diffuses it by sprays, sometimes under a slight vacuum; but subsequently some oxygen may enter the circuit again via condenser tube leaks from the cooling water, or some other source, before it enters the boiler. To combat this, and to remove the last traces of oxygen (0.03 to zero cubic centimetres per litre) sodium sulphite is introduced.

Reducing Corrosion

Much research has been done to discover the mechanism whereby boiler tubes become corroded and internally pitted. It is now generally accepted that this is caused by local electrolytic action (due to the difference in potential set up between aerated and unaerated portions of the metal; pits occur at anodic points of low oxygen concentration).

To minimise corrosion, caustic soda (sodium hydroxide) is added to make the boiler feedwater sufficiently alkaline. The use of caustic soda for the purpose, however, introduced another troublesome problem: namely caustic embrittlement of the steel pressure parts due to local concentration of the caustic, particularly in riveted seams. The caustic may also attack the grain boundaries of the crystal structure in the metal, wherever the metal is highly stressed, and initiate cracks. As a result of extensive research, methods of detection by indicators have been devised. It has also become possible to inhibit attack; this can be done, for instance, by maintaining a certain ratio of sulphate to caustic in the boiler water. In this connexion R. E. Hall, a pioneer American investigator, has recently suggested that potassium salts might be more suitable than sodium, especially for high operating pressures.

The carry-over of salts from the boiler water in the saturated steam, either in the form of a vapour in solution in the steam, or in suspended droplets of water, is still a major problem not completely solved. By means of various mechanical devices saturated steam purities are obtainable of the order of less than 1% of moisture and one part of salts per million. Even so, the latter figure represents in a boiler producing 200 tons of steam per hour continuously a carry-over of 1½ tons of salts per year—an appreciable amount. It is fortunate if some of it does not adhere to the turbine blades, or reside in the superheater tubes, ultimately causing a blockage which may result in their overheating and failure. Where the salts are soluble they can be removed by regular washing-out of the turbine and superheater. Much work has already been done to determine the factors responsible for carry-over, such as the nature and concentration of the dissolved and suspended solids in the boiler water, and their effect on the physical properties of the water as regards foaming and the stability of the steam bubbles. The quality of the steam is measured by condensing a

* Hydrogen ion concentration, a measure of the degree of acidity (or alkalinity).

† Similar to the material used in the well known domestic 'Permutit' softener.

DISCO

sample
tinuous
so that
steam

Invest

Refe
cooling
below
on the
extent,
compo
often p
on the
until i
transfe
resista
with it
pressu
high-p
The ch
of suc
format
temper
a defin
air hea
The
sion an
genera
with w
It is ge
the pr
dioxid
sulphic
moistu
in the

The
trioxid
labora
has be
have H
than
theory



sample and measuring its electrical conductivity. Continuously recording conductivity meters are now available, so that the boiler operator may be warned immediately the steam purity is dangerously threatened.

Investigation of Acid Deposits

Reference has already been made to the importance of cooling the gaseous products of combustion in the furnace below the softening temperature of the ash to avoid slagging on the boiler tubes. In spite of cooling the gases to this extent, another type of adherent deposit sometimes occurs, composed of bonded ash particles in which sulphates often predominate. Once a thin deposit of this type forms on the tubes, it will proceed to build up layer by layer, until it not only considerably reduces the rate of heat transfer, but eventually causes such an increase in draught resistance that the fan equipment may not be able to cope with it. Steam blowers projecting powerful jets of high-pressure steam will not always remove it, although lately high-pressure water jets have been tried with some success. The chemical action which is responsible for the incidence of such deposits is not fully understood. Possibly the formation of traces of sulphuric acid in the gases at high temperatures is a factor, since somewhat similar deposits of a definitely acidic character are found in economisers and air heaters.

The latter type of deposits naturally cause severe corrosion and have been responsible for a considerable loss of generating capacity especially of stoker-fired boiler plants, with which type of firing they are predominantly associated. It is generally agreed that free sulphuric acid is formed in the products of combustion by oxidation of the sulphur dioxide, which results from the burning of the pyrites (iron sulphide) in the coal, to the tri-oxide; this then absorbs the moisture produced by the combustion of the hydrogen in the fuel to form sulphuric acid.

The mechanism of the oxidation of the dioxide to the trioxide is obscure and has been the subject of prolonged laboratory and field research. Generally the experience has been that boilers with higher superheat temperatures have had more trouble from acid corrosion and deposits than those with lower superheat temperatures. One theory is that the red oxide which forms on the outside of

highly heated superheater tubes provides the necessary catalyst for the oxidation process. The seriousness of the situation is aggravated by the fact that the presence of sulphuric acid vapour in the gases raises their dew point considerably, so that the acid in solution in the moisture of combustion condenses readily on the low temperature sections of the heat reclaiming equipment. The kind of coal and its sulphur content are not the decisive factors, although other conditions being equal a coal of high sulphur content produces more acid.

Fortunately with pulverised fuel, acid corrosion is almost unknown. It has been suggested that the fine light ash obtained with this type of firing forms a thin protective layer over the oxide on the superheater tubes, inhibiting its catalytic action. If this is so there exists the possibility that a suitable agent may be discovered that can be applied to the high temperature superheater tubes in stoker fired boilers to form a permanent protective coating. Investigations on these lines are in progress.

New Materials and Constructional Methods

The strength (more precisely, the yield point) of mild steel falls off considerably with increase in temperature, and this decline is more marked above 800° F. Despite the desirability of operating at high steam temperatures and pressures to obtain the gain in efficiency which steam table research indicated, it would not have been practicable except for the fact that the researches of metallurgists have resulted in finding alloys capable of withstanding these onerous conditions.

Apart from corrosion, the other main problem at high temperatures is 'creep'. Creep is not to be confused with either the elastic deformation of a metal, or its normal expansion due to heating. Creep is a gradual deformation under load due to slipping of the crystal planes; it is more evident in highly stressed metal at high temperatures. The phenomenon has been fully investigated during the last fifteen years. It entailed very accurate measurement of the rate of extension of specimens under conditions of constant loading and thermostatically controlled high temperature over long periods of time. As a result of research, special machines are now available and accelerated short time tests have been devised to give the information required regarding the creep properties of a metal within a few days, instead of having to wait several weeks or months while the specimen slowly extends.

The amount of creep permissible depends on the function of the particular mechanical part. For instance, if the bolts in the flanges of a high pressure steam pipe extend in the course of time, due to creep, beyond a certain limit, the joint will leak. In deciding on the permissible creep limit of a structure the criterion is the period of service demanded of the unit without adjustment or renewal. Plain carbon steel has an undesirably high creep rate at temperatures above 800° F., but the addition of half of one per cent of molybdenum greatly improves its qualities in this respect. For steam temperatures above 900° F. chromium-molybdenum steel is often used; at 950° F. it has a very low creep rate and its safe working stress is more than twice that of mild steel at the same temperature. For structural supports exposed to the furnace gases there are heat- and corrosion-resisting

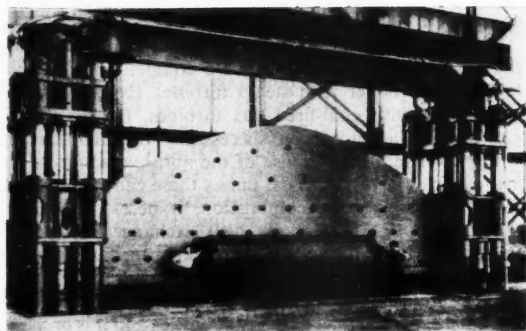


FIG. 4.—The largest boiler-plate bending press in the world, capable of cold-bending boiler plate up to 7 in. thick and in lengths up to 40 ft. (Courtesy, Combustion Engineering Co. Inc.)

alloys of the high chromium type (over 12% chromium) available.

One of the problems occupying the attention of metallurgists at the moment is the 'graphitisation' of steel. Graphitisation is the separation of the carbon and iron originally chemically combined in the steel into graphite (a crystalline form of carbon), and ferrite (pure soft iron). It has been found that in some cases after high-temperature steam pipes have been in service for some time the metal at welded joints has gradually been weakened by this slow conversion of the steel to the ferritic form, which has the characteristics of wrought iron with a much lower yield point than the original high tensile steel. In these circumstances there is a danger of the welded joints failing due to excessive stress.

While alloy steels are necessary for highly superheated steam, they are not essential for the saturated steam parts which, under normal operating conditions, never exceed 700° F. due to the cooling effect of the water, so that the drums and tubes concerned solely with the function of evaporation have in Britain been, with few exceptions, manufactured from the cheaper plain carbon steels. Nevertheless, new methods of manufacture have had to be evolved to deal with the increased thickness of drums necessary to withstand the greater pressures. Boiler drums up to 2 in. thick can be manufactured from rolled plates joined by riveting, but high pressure drums require wall thicknesses of 3 to 6 in. thick, and are usually forged in this country from solid ingots, which for a drum 54 in. internal diameter and 30 ft. long may weigh initially about 150 tons. (Fig. 5.)

In the U.S.A. attention has been more concentrated on the welding of drums, although lately the technique has made great strides in this country. After bending the plates (Fig. 4), the seams are electrically fusion welded and then examined by X-rays for cracks and slag inclusions in the weld metal. The conclusions of radiographic research have enabled a satisfactory industrial technique to be evolved, as a result of which welding is now accepted by the leading inspection authorities in this country. Very high voltage X-ray units are required to penetrate steel 6 in. thick. Units up to 2 million volts capacity are in use.

Future Developments

Ever since the upward trend in boiler operating pressures commenced, certain engineers have from time to time expressed anxiety about the continued satisfactory functioning of natural circulation. However unfounded their pessimism may have been, it has resulted in the development of a number of interesting types of forced circulation boilers, in which the water is pumped through the boiler tubes; a few of which have taken their place in the steam generating industry, although not to any great extent. At the moment there does not seem to be any

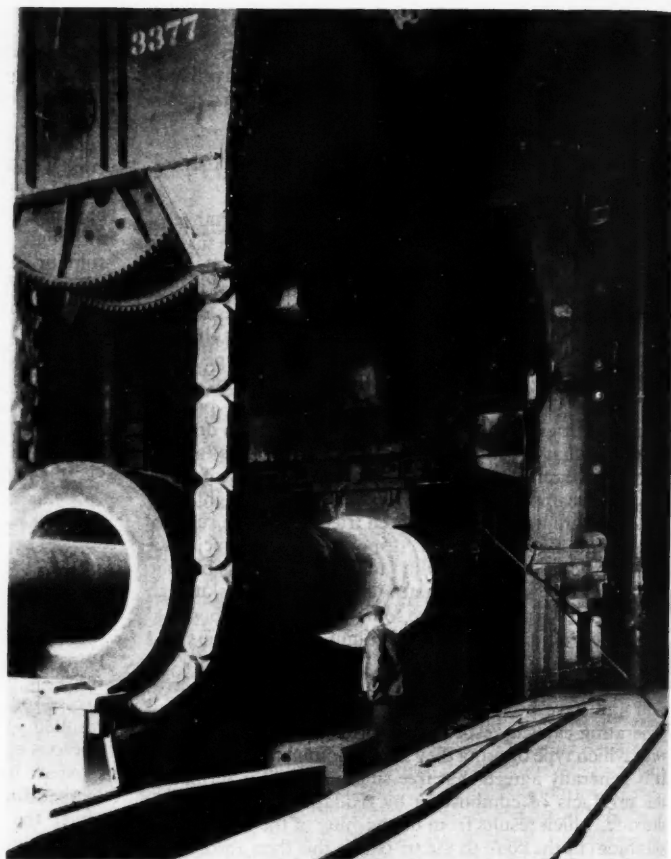


FIG. 5.—Forging a large boiler drum, under 7000-ton electro-hydraulic press. (Courtesy, English Steel Corporation.)

pronounced tendency to extend working pressures above 1500 lb. per sq. in., and up to this pressure natural circulation designs have proved to be satisfactory. Examples of forced circulation boilers operating in this country, are the La Mont, Sulzer and Loeffler. Looking ahead, some form of forced circulation boiler may eventually be used for the controlled conversion of atomic energy into steam power.

It is possible that in the future, for ship propulsion, the oil-fired gas turbine may be a competitor of the oil-fired marine boiler with steam turbine. Experiments are proceeding with coal-fired gas turbines, but so far the gas turbine has not been successfully operated directly with pulverised fuel because of the abrasive action of the ash particles at high speeds; unless these can be separated from the products of combustion, it necessitates either the interposition of a large heat exchanger to transfer the heat to clean hot air as the working medium—experimental plants have been constructed on this principle—or the pre-gasification of the coal. Coal still remains the most economic fuel in many countries and it is probable that the 'water-tube boiler/steam turbine' combination will remain for some considerable time yet the cheapest and most reliable large scale method of converting the chemical energy of coal into mechanical and electric power.

PEOPLE
thrown
reveale
plants
and sta
washin

Nor
which v
soldiers
the Far
enable
and to
plants.

Plan
drinking
thrown
handbo
intense
listed.
of them

Amo
lives, t
(Cocos
Its larg
vegetab
at any
value t
it conta

Another
Nipa p
are usu
the coc
graded

Large
palms
Metrox
are spl
the sta
almost
roasted
comme
palms
are not
stinging

The
breadfr
yams—
bulbifer
phylla)
size and
them fo
them w
three o
caution
poison

The
to the
green l
which a
purple

These Plants Saved Lives

PEOPLE, inventions, even animals, have had the limelight thrown on them as the part they played in the war was revealed. So far little credit has been given to the jungle plants which often alone stood between the jungle soldier and starvation and thirst; some of them helped to solve the washing problem, and others even caught fish for him.

Nor has recognition been made of the botanist's services, which were made available in small handbooks issued to the soldiers of Australia and America and to British airmen in the Far East. These booklets gave sufficient information to enable the lost flyer or soldier to live in and off the jungle, and to distinguish between food plants and poisonous plants.

Plants which can be used as vegetables, or as a source of drinking water, or which can be used to stupefy fish when thrown in a pool, are described and often pictured in the handbooks. Poisonous plants and vegetation which causes intense itching or stinging when brushed against are also listed. The native names, in some cases twenty or thirty of them for the one plant, are given.

Among the plants which undoubtedly saved many lives, the most important was the ubiquitous coconut (*Cocos nucifera*), which can satisfy both hunger and thirst. Its large terminal cabbage-like bud can be cooked as a vegetable, or eaten raw. The flesh of the nut can be eaten at any stage of development. The nut has proved of most value to stranded soldiers for the sterile drinking water it contains.

Another palm of salt or brackish waters is the stemless Nipa palm (*Nipa fruticans*). The young immature seeds are usually edible and somewhat resemble the 'meat' of the coconut in taste. When ripe, the seeds have to be grated or crushed before eating.

Large quantities of starch are stored in the stems of palms belonging to the *Corypha*, *Arenga*, *Caryota* and *Metroxylon* genera. After felling the palms, the stems are split, the soft inner parts of the trunk crushed and the starch washed out into troughs to settle. This gives almost pure starch, which can be made into cakes and roasted or baked. The best stems to use are those just commencing to flower. The terminal buds of some of these palms can be used as a 'cabbage', but most of their fruits are not edible and may even be dangerous owing to the stinging needle-like crystals in them.

The yam, taro, cassava, palm lily, water lily root and breadfruit also provide starch. All the five common yams—the greater yam (*Dioscorea alata*), the bulb yam (*D. bulbifera*), goa yam (*D. esculenta*), buck yam (*D. pentaphylla*) and wild yam (*D. hispida*)—have starchy tubers the size and shape of a man's forearm. The best way to prepare them for eating is to cut them into thin slices, then coat them with ashes and soak in a stream of salt water for three or four days, afterwards drying in the sun. Great caution is necessary with these tubers as they may contain poisonous substances unless well washed.

The taro (*Colocasia esculenta*), in appearance similar to the arum lily, is about four feet tall with large dark green leaves and grows in damp places. The leaf stalks, which are coloured red or purple, join the leaf at a blue or purple spot. The underground turnip-shaped tubers are

cooked like potatoes. The young leaves, too, can be boiled to give a kind of spinach.

The cassava, or tapioca plant (*Manihot esculenta*), is a shrubby plant three to five feet high and is widely cultivated in the Tropics. The large roots are very rich in starch, but because there are two similar varieties, one bitter and poisonous, the other sweet; the roots have to be cooked to make sure there is no prussic acid, the poison that makes the bitter cassava dangerous. Usually bitter cassava stems have red veins whereas those of the sweet cassava are white.

Another cultivated plant often found in or near native villages is the sweet potato (*Ipomoea batatas*). It is a climbing perennial, with typical convolvulus-like pink flowers and heart-shaped leaves. The edible part is the club-shaped swollen root, which can be eaten raw or cooked. The young shoots and leaves make an excellent vegetable.

The fifty-foot-high breadfruit tree (*Artocarpus altilis*) which has large, glossy, lobed leaves, yields fruits which can be baked whole. These round, dark-green fruits, about the size of a melon, have many seeds if they are the wild variety, but are almost seedless if cultivated. The fruit tastes like boiled potatoes mixed with sweet milk.

The banana is too well known to be described. But in addition to the well-known banana there are small varieties, some only finger-size and others the size of a man's arm. They are only found near villages, and never occur in the high forest.

The pawpaw or papaya (*Carica papaya*), a small tree six to fifteen feet high with large fig-like leaves and big melon-shaped fruits, is commonly found near villages. The ripe fruits, which contain the enzyme known as pepsin, are very popular. The young fruits, young leaves and flowers can all be cooked and eaten as vegetables. (These fruits must not be carried next to the skin as their juice may cause intense irritation and inflammation.)

The cashew (*Anacardium occidentale*), a small or medium-sized tree, gives an oily nut which is found at the bottom of the cashew fruit. The juicy fruit itself, yellow or purple in colour, is very refreshing.

Other fruits available in the jungle include the mango (*Mangifera indica*), on a glossy-leaved thirty-foot-high tree, the custard apple (*Annona reticulata*) on a fifteen-foot-high tree, the guava (*Psidium guajava*) with white flowers and pale-greenish or yellowish-green, smooth, many seeded fruits on a five- to fifteen-foot-high shrub.

Citrus fruits, figs, sugar cane, and peanuts (*Arachis hypogaea*) borne under the soil, are found near villages, while the wild raspberry, Malay apple (*Syzygium malaccense*), rose apple (*Syzygium jambos*) and santol (*Sandoricum koetjape*) with round yellowish fruits, can be found growing wild or semi-wild near villages.

Green vegetables are provided by *Cycas circinalis*, a palm-like plant often found near the sea, whose very young leaves give an asparagus-like dish, and the hyacinth bean (*Dolichos lablab*), a vine with violet or white flowers giving edible pods which are pink or reddish when young. They can be cooked and eaten like runner beans.

At a pinch the young soft curled fronds of the thousands of ferns make good vegetables, or can even be eaten raw.

Water, often difficult to find in a pure condition even in wet jungles, can be obtained from some vines which store considerable amounts of water in their stems. Among them is the Rattan palm (*Calamus spp.*), a spiny climbing plant which gives the well-known rattan cane. By cutting the stem into sections, and holding them upright, water flows out in a small stream from the lower ends. The Nipa palm fruits may also contain liquid, as do coconuts.

In addition to food and drink, the jungle yields a substitute for soap and plants for catching fish. Red Ash (*Barringtonia asiatica*), a large 100-foot-high tree with large smooth leaves and pink flowers with many stamens, gives soap substitute. A handful of leaves or bark chips rubbed vigorously with water provides an efficient lather.

The large fruits of this same tree if crushed and thrown into pools will kill fish.

The rotenone contained in the roots, leaves and stem of *Derris elliptica* makes this woody vine with the bean-like flowers an excellent source of fish poison. (The same active principle is also effective against insects, and derris dust is familiar enough to gardeners.) This property has gained the plant the nickname of 'New Guinea dynamite'!

Among the most dangerous plants against which troops serving in the tropics were warned are the strychnine plant (*Strychnos spp.*), the bitter cassava, and the common castor oil plant (*Ricinus communis*), whose seeds must be avoided as they are a violent purgative.

RICHARD CLEMENTS, B.Sc., F.L.S.

Four Films about Soil

THE growth in importance, during recent years, of the scientific or technical film intended for a specific audience has been largely due to the wartime need for intensive instruction in the Services, Civil Defence and industry. Such films have therefore in the main been purely instructional—Training Films as they are usually called. The specific-audience film is not, however, confined simply to training in the ordinary sense of the word, and probably at the opposite end of the scale we should place the 'Report' film, designed for specific and specialised audiences. Two examples of this are the Army Personnel Selection films reviewed in the May issue of DISCOVERY.

In between, there is the type which borders on the purely instructional while combining something of the style and approach of the 'Report'. Films of this class serve both to whet the appetite, and to sum up knowledge and aid clearer thought. A series of four films on Soil, made by Realist Film Unit for I.C.I. with the co-operation of the Ministry of Agriculture, fall in this class. They are *Factors of Soil Fertility*, *Lime*, *Land Drainage* and *Soil Nutrients*, and are intended for Young Farmers' Clubs and Agricultural Colleges. *Lime* runs for 10 minutes, each of the others for 20 minutes.

The director of this series, Brian Smith, has made four interesting, lively films, which should be of considerable appeal not only to specialised agricultural audiences but to more general ones as well. This he has achieved largely through a very human, and often humorous, handling of his material.

Factors of Soil Fertility deals generally with the balance of soil conditions affecting yield; it is perhaps a fault of the series as a whole that this film overlaps rather too much with the other three. The four main requisites are shown to be an adequate supply of air and moisture for the roots, a properly balanced diet, ('diet' and 'food' are terms the plant physiologist usually shun, but the use of the word 'diet' seems well justified here, bearing in mind the audience to which these films are directed), the correction

of acidity and the prevention of diseases; only if each separate requirement is properly looked after can a good crop be anticipated. These four factors are dealt with in turn but without losing sight of their mutual relationship; clear, well-planned animated diagrams help in this correlation.

Availability of air and water to the roots depends largely on the crumb structure of the soil, the importance of which is shown by models. Turning to 'diet', the essential fact is pointed out that in the grain and straw harvested from a field there is taken away a proportion of the nutrients they have absorbed from it: these must be replaced before an equally good fresh crop can be grown in the same field. Laboratory sampling determines these deficiencies; and at the same time the pH test tells the farmer the amount of lime needed to satisfy the third requirement, acidity correction. The serious effect of acidity is shown by speeded-up comparison shots of barley growth in two boxes. (A similar technique is also used in two of the other films.)

The fourth factor, prevention of diseases and pests, is treated somewhat sketchily and more could well have been said about this. The film ends by stressing that every crop in the country will be as good as the worst, not the best, of these four main factors.

Lime extends and amplifies the subject of acidity correction. The importance of avoiding overliming is stressed, and attention drawn to the fact that whereas a hundred years ago liming was just guesswork, today the agricultural chemist is able by analysis to prescribe the exact amount of lime for any particular soil. An interesting sequence shows the various sources of lime—chalk or limestone deposits and quarries and, in parts of Cornwall, beach sand containing minute particles of sea shells.

Land Drainage is in many ways the best film of the series. Adequate soil drainage is necessary to prevent waterlogging and hence lack of air for plant roots. Having established this the film goes on to show, with some excellent animated diagrams,

what a Catchment Area is and how some parts of it are well drained naturally whilst others need artificial drainage. The techniques of interception ditching, tile drainage and mole drainage are dealt with clearly, and there are some interesting shots of the ingenious machine that does these jobs. Common causes of drainage trouble are shown, such as a blocked culvert or tunnel, underneath a field gate.

Soil Nutrients, after some general remarks on manure and the best way of storing it, demonstrates the importance of soil microbes in maintaining plant life. The nitrogen cycle is illustrated by good molecular models. An alternative source of nitrogen is synthetic nitrate fertiliser and the film shows, with a touch of irony, the huge industrial plant which does the same chemical job as the nitrogen-fixing bacteria. Sources of potash and superphosphates, the two other main nutrients, are also shown—for instance, basic slag from steel furnaces.

The film then explains in detail the importance of having the soil analysed. Deficiencies of the main elements—nitrogen, potassium, phosphorus—may be fairly obvious to a trained eye: spectroscopic analysis is, however, the only certain way of detecting the presence or absence of the other metallic salts also needed in small amounts by crops. The principle of the spectroscope is here clearly and simply explained. This sequence demonstrates effectively the necessity to the farmer of scientific soil analysis.

These four films will undoubtedly help farmers and students alike to appreciate the help science can bring to their work. Balance between theory and practice is well maintained throughout; the farmer is made a human being, not merely a figurehead. The outdoor photography brings with it a pleasant feeling of fresh air, and the commentary is informal and easy flowing. The subject as a whole, which might well have become dry-as-dust (or dull as ditch-water) has been made lively and entertaining.

DENIS SEGALLER

(This review is contributed by arrangement with the Scientific Film Association.)

Radar:

By R. & Ha

This book principles of war, the radar of craft of coming invariab ledge, a ligible to F. A. Pil to work book is

An in to intere gives son and its of radar craft wit describe of direct tion of on range properti echoes e ing the five chap tube, ar millionth of an air of an air its direc angle of and some measure

There these pr experim the war, not expl of adap use by s tions. Th the rada the vast ing the v uses for

The b nation, most of educati the parts cult for For the be soug will pu plicated sketches other es

The r grammar the last Neverth portant in expl only ta seconda science life, and knowle tive for out of o

es and stem of
the bean-like
n. (The same
acts, and derrick
s property has
nea dynamite!
which troops
the strychnine
d the common
seeds must be

B.S.C., F.L.S.

and how some
ined naturally
cial drainage.
ption ditching,
image are dealt
ome interesting
chine that does
es of drainage
as a blocked
th a field gate.
some general
ne best way of
importance of
ing plant life.
rated by good
ernative source
itrate fertiliser
ouch of irony,
which does the
nitrogen-fixing
sh and super-
main nutrients,
nce, basic slag

in detail the
soil analysed.
n elements—
horus—may be
eye: spectro-
er, the only
the presence or
ilic salts also
y crops. The
is here clearly
his sequence
e necessity to
analysis.

undoubtedly
like to appre-
poring to their
theory and
throughout;
an being, not
the outdoor
it a pleasant
ommentary is
The subject
have become
h-water) has
entertaining.

SEGALLER

l by arrange-
Association.)

The Bookshelf

Radar: Radiolocation Simply Explained.

By R. W. Hallows. (London, Chapman & Hall, 1946; pp. 140, 7s. 6d.)

This book attempts to explain the principles of radar from 'scratch'. During the war, the author was a chief instructor of radar operators at one of the Anti-Aircraft Command schools. These operators, coming from all walks of life, were invariably without any technical knowledge, and methods of instruction intelligible to all had therefore to be devised. It was the author's task, as General Sir F. A. Pile states in a foreword to the book, to work out these new methods, and the book is largely based on this experience.

An introductory chapter is designed to interest the reader in the subject and gives some details of the history of radar and its vital role in the war. The essence of radar, as a means of locating an aircraft without its knowledge or assistance, is described by contrast with other methods of direction-finding in which the co-operation of the aircraft is required. Chapters on range-measuring by sound echoes, the properties of wireless waves, and wireless echoes explain the possibility of estimating the range of aircraft. Then follow five chapters on electrons, the cathode-ray tube, and how this is used to measure millions of a second and the exact range of an aircraft. To determine the position of an aircraft it is also necessary to know its direction and angle of elevation (or angle of sight) from the radar station, and some of the methods of making these measurements are explained.

There is a short description of how far these principles were being applied for experimental scientific purposes before the war, and the author stresses (but does not explain in any detail) the big problem of adapting experimental apparatus for use by service personnel in active operations. The two final chapters describe how the radar principle was applied to make the vast variety of instruments used during the war, and briefly mention its future uses for navigation and other purposes.

The book by itself, without oral explanation, will probably be understood by most of those who have had a secondary education, but sections of it, particularly the parts dealing with waves, will be difficult for those who left school at fourteen. For these an even simpler approach must be sought. The photographs of apparatus will puzzle many because of the complicated detail: the addition of geometrical sketches to show the aerial arrays and other essential features would help.

The methods of explanation and diagrammatic presentation are certainly not the last word in teaching technique. Nevertheless, the book is sufficiently important in that it succeeds substantially in explaining what before the war was only taught, if at all, in the last years of secondary school. The rapid advance of science and its applications to everyday life, and the need for citizens to have a knowledge of these facts, make it imperative for new paths of learning to be worked out if our education is to be brought up

to date. This book shows what was done in an important field during the war to simplify the presentation of highly technical ideas.

ROY INNES

The Gyroscope and its Applications.

Edited by Martin Davidson. (London, Hutchinson, 1946; pp. 256; 21s.)

Those interested in gyroscopes will find here, in a well produced and lavishly illustrated form, a reliable introduction to the theory and a general survey of the practical applications of present-day importance. Dr. M. Davidson has done the general editing and has written Section I on General Theory. The early part of Section I is purely elementary and can be read and understood by those who have no knowledge of dynamics, while later on this section provides some mathematical theory for those who wish to base their understanding of the gyroscope on rather more than an account of simple experiments. Thus all categories of readers can bring a sound knowledge of gyroscopic principles to Sections II and III, which deal with marine and aeronautical applications.

G. C. Saul, writing Section II, has included detailed descriptions of the Sperry, Brown and Anschütz Gyro Compasses, and very clear accounts of the Marine Gyro Pilot and gyroscopic stabilisation of ships by the Sperry and Denny Brown methods, concluding with a chapter on the gyroscope in the torpedo.

Section III, by J. A. Wells and A. P. Glenny, is essentially more difficult reading, covering as it does the very wide range of aeronautical applications. The account here of such things as direction indicators, rate of turn indicators, gyroverticals, automatic pilots, etc., will probably be of considerably interest to the many flyers who have been using these instruments during the war without the opportunity of going far into their fundamental principles and methods of operation.

S. J. BROOKFIELD

From Savagery to Civilisation.

By Grahame Clark. (Cobbe Press, London, 1946; pp. 112; 7s. 6d.)

PROFESSOR Gordon Childe's brilliant trilogy *Man Makes Himself*, *What Happened in History* and *Progress and Archaeology* has, in the last ten years, made available to the general reading public his synthesis of prehistory which, for the first time, clearly discerned the early history of man through the growing confusion of excavation reports and archaeological surveys, and constituted the major advance made in prehistoric methodology since Thomsen devised his scheme of the three ages—Stone, Bronze and Iron. Childe, building on the earlier schemes of Tylor and Elliott Smith, recognised human history as a progression from the *Savagery* of the Palaeolithic and Mesolithic, through the *Barbarism* of the Neolithic and Copper Ages that succeeded the Neolithic Revolution, to the *Civilisation* of the Bronze Age introduced by the Urban Revolution.

Any new survey of prehistory must be heavily indebted to Childe's synthesis. In this short book, Dr. Grahame Clark takes Childe's scheme and gives a lucid account of man's history from the beginnings of his culture to the origins of civilisation—the culture of the early dynastic cities of Egypt and Mesopotamia, prefacing his account of this cultural evolution with a welcome short summary of man's physical evolution. Clark uses Tylor's terms for his main groupings, and it is a measure of our advance in prehistoric archaeology that such a book as this can now be written around a framework other than the arid one of the three technological ages of man. Clark uses the term *Lower Savagery* to describe the Lower and Middle Palaeolithic of the older systematists, *Higher Savagery* for the Upper Palaeolithic and Mesolithic, and *Primitive Barbarism* for the first food-producing cultures of Merimde, Tasa, the Fayum, and Sialk I. The systadial village of Hassuna was published while this book was being printed. He distinguishes between the 'primitive' barbarism of these villages and the 'modified' barbarism of the homotaxial villages in prehistoric Europe, which owed much to survivals of the higher savagery and to contacts with urban civilisation. In a book of this size he rightly concentrates on the essentials of his story and has to forgo any account of the prehistory of Europe, India and China—subjects which may be dealt with in later volumes in the series of which this book is the first.

Dr. Clark's account is well illustrated with plates and text figures, and of particular value are his two tables summarising the main cultural inventions from Savagery to Civilisation. This book is the first in a series of forty entitled *Past and Present: Studies in the History of Civilisation designed to show how history can help*. If all the volumes are of the high standard set by Clark, they will be invaluable to all serious students of human history. Here at least is the most admirable summary of how Prehistory can help.

It is a pity that the high price of the book precludes the very widest circulation which it deserves, but presumably a cheaper edition would mean a sacrifice of the standards of printing and illustration which the editors of the series have set themselves.

G. E. DANIEL

Of Ants and Men.

By Caryl P. Haskins.

(Allen & Unwin, London, 1946; pp. 244; 10s. 6d.)

This book is divided into the following chapters: Earth Dwellers—The Dawn—The Ants of Today—Ants and Men as Individuals—The Rise of the City—The Ties That Bind—The Ant Colony as a Multicellular Organism—Fascism or Communism?—War—Slavery—The Tributary Peoples—The Fate of the Primitives—In the Future.

On page ii it states that this work was first published in 1945. This is not the case, for the original edition, which

I possess, is dated 1939. The letterpress, illustrations, pagination, etc., are identical.

Professor Haskins has studied live ants for many years, and is very capable of discussing their social life. His comparisons between the societies of ants and men which are frequent, are sound, and do not stress anthropomorphism unduly. It is suggested that the evolution of the social habits of ants concluded over 50 million years ago, whereas that of man is practically just beginning. Our present knowledge of ants is incomplete, which gives scope for the labours of future myrmecologists.

To criticise one or two small points: on p. 77 it is stated that eggs laid by worker ants are infertile and only add to the burden of male rearing. This is not the case, as under certain conditions worker eggs produce workers.

On p. 117 pseudogynes are said to have little energy and are lazy and ineffective. This is not always so: I have kept a small colony entirely composed of pseudogynes, and they were quite as active and effective as ordinary workers.

There are a few other errors which might be mentioned, space allowing, but they do not detract from the interest of this very fascinating book, which I can recommend to all myrmecologists.

HORACE DONISTHORPE

Electricity—Public or Private Monopoly?

By F. HAMLYN DENNIS. (Gollancz, London, 1945; pp. 144, 7s. 6d.).

If the Electricity Bill which resulted in the 1919 Electricity Act had not had its provisions for the compulsory establishment of Joint Electricity Authorities deleted, would there have been any need for the 1926 Electricity Act, which brought the Central Electricity Board into being? And if the 1926 Electricity Act had been accepted in the form of the original Bill, should we have had the present controversy on the future form of administration of electricity supply and distribution?

These questions come to mind on reading the book by Mr. F. Hamlyn Dennis entitled *Electricity—Public or Private Monopoly?* Mr. Dennis surveys, in as impartial a manner as possible, the history of the development of the electricity generation and supply industry. In the introduction it is stated that the book should appeal to all classes of people and should bring about a better understanding of the problems involved in reorganising the industry. Within the limits that permit a complicated and technical problem to be presented to those outside the industry, the book should succeed in its purpose.

On certain matters it is clear that the author is not personally conversant with the factors upon which he has based his

conclusions. The statement on p. 24 that "The extension of this form of ownership (by Joint Electricity Authorities) would go a long way towards the solution of distribution problems" is open to question. J.E.A.s are ideal authorities for co-ordinating generation—and it has been said with some authority that the compulsory formation of J.E.A.s under the 1919 Electricity Act would almost certainly have abrogated the need for the 1926 Act. But all the evidence is to the contrary that J.E.A.s can be successful as distribution authorities.

In surveying the development of generation and the formation of the Central Electricity Board, the author has commented very shrewdly by quoting from *Hansard*. Statements made in Parliament by the 'experts' of that day (1926), such as Mr. George Balfour, are given to show that they were sincerely of the opinion that a Central Electricity Board would be unworkable, yet during the recent war the existence of a national 'grid' and the operation of the Central Electricity Board was probably one of the major factors that contributed to our success. Again, however, the statement on p. 80 that "station staffs are faced with divergent interests—not conducive to operating at the highest level of efficiency" is a generalisation which is untrue. The author's conclusions with regard to district heating are open to a similar criticism. In considering the need for reorganisation, the author rightly points out that "the industry has failed to devise any joint plan for an effective organisation". He refrains from referring to the claim made fallaciously in the I.M.E.A. Joint Memorandum that efficiency can be measured by the yardstick of increased sales but he does definitely hold the view that electricity supply should eventually come under public ownership.

The book is a reasonably impartial survey of all the complex problems which are inherent in any change of ownership of electricity undertakings. References are made (with excellent footnotes) to a wide range of literature on the subject and it is rather a pity that a short index was not included. It is probably the best exposition on this subject that has yet been published. J. A. SUMNER

The New Plastics. By Herbert R. Simonds and M. H. Bigelow. (Van Nostrand, New York, 1945; pp. 320; \$ 4.50.)

THE literature of plastics is very scattered, and compilations exemplified by this volume are useful in so far as they help anyone searching for details about recent developments. This book, which covers the period from 1940 to March 1945, is "supplemental to earlier books on plastics", to quote the preface. One finds in it particulars about, for example, polythene, Saran and silicones. Improvements in the well-established acrylate, phenolic, urea and casein resins are recorded. Then there are separate chapters dealing with new adhesives, synthetic rubbers, and new textile fibres—in the last-mentioned details are given of Aralac, nylon, vinyon, velon, polystyrene and soybean fibres, and Fortisan.

Night Sky in August

The Moon.—Full moon occurs on August 12d 22h 26m, U.T., and new moon on August 26d 21h 07m. The following conjunctions take place:

August			
3d 01h	Jupiter in conjunction with the moon,	Jupiter	4 S.
24d 16h	Saturn ..	Saturn	3 S.
25d 11h	Mercury ..	Mercury	4 S.
29d 18h	Mars ..	Mars	5 S.
30d 11h	Venus ..	Venus	6 S.
30d 18h	Jupiter ..	Jupiter	3 S.

In addition to these conjunctions with the moon, the following conjunctions occur:

August 9d 14h, Venus in conjunction with Mars, Venus 0.6 S.; August 31d 00h, Venus in conjunction with Spica, Venus 0.2 N.

The Planets.—Mercury rises at 3h 27m in the middle of the month and at 3h 52m at the end of the month and is visible in the eastern sky. The planet is in inferior conjunction on August 2 and is stationary on August 12. Venus is conspicuous in the west after sunset, her times of setting being 21h 12m, 20h 36m, and 19h 53m, at the beginning, middle and end of the month respectively. The stellar magnitude of the planet varies from -3.7 to -3.9 during August. Mars sets at 21h 18m on August 1 and 20h 37m on August 15, the latter being about 1h 10m after sunset, so that the planet is not very favourably placed for observation during the greater portion of the month. Jupiter sets at 22h 04m on August 1 and can be

seen in the western sky in the constellation of Virgo. At the end of the month the planet sets at 20h 14m, or 1h 23m after sunset and will not be so favourably placed for observation then. The stellar magnitude of Jupiter is 1.5 at the beginning and 1.4 at the end of August, the decrease in brightness being due to the fact that distance of the planet from the earth varies from 527 to 564 million miles during this period. Saturn rises at 3h 40m and 2h 02m at the beginning and end of the month respectively, but in the former case is too close to the sun to be well observed.

The Perseid meteors are active throughout a large portion of the month and attain their maximum on August 10-12, but as the moon is full on August 12 the shower cannot be observed at its maximum.

The constellation of Perseus contains a number of interesting objects and two of these can be observed with field-glasses. It is easy to identify α Persei but if there is any doubt draw a great circle through γ and ζ Urs. Maj. and it will pass close to α Persei. A pair of field-glasses will show a very fine array of stars in the neighbourhood and this is an impressive sight. Near the star ζ Persei, which is rather faint and not easy to identify, there is a beautiful star cluster which is visible on a clear night to the naked eye. As it is near the border between Perseus and Cassiopeia it can be found by searching this region, either with field-glasses or if the conditions are favourable, with the naked eye.

M. DAVIDSON, D.S.C., F.R.A.S.

Atomic E
At the fi
Commis
in New
Baruch
plans fo
The U.S.
lines of
and pro
national
This wou
materials
entrusted
and use
Authorit
facture o
all existi
The Au
possessio
the pro
United S
secrets
penalties
treaty, su
atomic b
The fir
one that
was prop
five Gre
shall not
the Auth
must be
violate
develop
tive purp
Strong
from the
Atomic
the veto
in essen
securing
after the
stocks of
The fu
propos
Soviet I
importa
the natio
decision
of atom
to use a
stances,
keeping
energy.
Convent
stocks
weapons
On Ju
mission
mittee
trolling
The Ato
THE in
Scientist
ingham
ingham
W. Mas
the first
announc
H. S.
Oliphant
Professo
Dr. E.

Far and Near

Atomic Energy Commission Meets

At the first meeting of the Atomic Energy Commission of the United Nations, held in New York on June 14, Mr. Bernard Baruch presented the U.S. Government's plans for the control of atomic energy. The U.S. scheme closely followed the lines of the Lilienthal (Acheson) Report, and proposed the creation of an international Atomic Development Authority. This would own or control all atomic raw materials and plant, and would be entrusted with all phases of development and use of atomic energy. Once the Authority had been set up, the manufacture of atomic bombs should stop and all existing bombs would be destroyed. The Authority would come into full possession of technical information about the production of atomic energy, the United States relinquishing its monopoly secrets by stages. There would be penalties for all violations of the proposed treaty, such as illegal possession or use of atomic bombs.

The final point in the U.S. plan was the one that has caused most controversy. It was proposed that the right of veto of the five Great Powers in the Security Council shall not operate in the directing body of the Authority. As Mr. Baruch said, "There must be no veto to protect those who violate their solemn agreements not to develop or use atomic energy for destructive purposes."

Strong opposition to the plan has come from the Russian representative on the Atomic Commission who is insistent that the veto must remain. The Russian line in essence was that discussion of ways of securing atomic control ought to wait until after the United States had destroyed its stocks of atomic bombs.

The full details of the Russian counter-proposals have been published in full in *Soviet News* (June 25), and the most important suggestion they contain is that the nations should declare their unanimous decision to forbid the production and use of atomic weapons and undertake (a) not to use atomic weapons under any circumstances, (b) to forbid the production and keeping of weapons based on atomic energy, (c) within three months of the Convention becoming effective, to destroy stocks of finished and semi-finished weapons.

On June 25 the Atomic Energy Commission agreed to set up a working committee to study all proposals for controlling atomic energy.

The Atomic Scientists Association

The inaugural meeting of the Atomic Scientists Association was held at Birmingham University, Edmund Street, Birmingham on June 15, with Professor H. S. W. Massey in the chair. The elections to the first Council of the Association was announced; its members are: Professor H. S. W. Massey, Professor M. L. Oliphant, Professor P. M. S. Blackett, Professor R. E. Peierls, Dr. J. Rotblat, Dr. E. H. S. Burhop, Dr. N. Kurti, Dr.

T. G. Pickavance, Dr. W. J. Arrol, Professor N. F. Mott, Dr. H. W. B. Skinner and Mr. W. G. Marley. Dr. S. Devons, Dr. K. F. Chackett, Dr. N. Kemmer, and Dr. G. O. Jones were afterwards co-opted.

During the meeting the statement of Mr. Baruch to the Atomic Energy Commission of the United Nations Organisation was brought up and in order to test the feeling of the meeting and in spite of the lack of time for consideration of the full text of the U.S. proposals, a resolution was proposed by Dr. G. O. Jones of Oxford in the following terms: "This meeting views with great satisfaction the report of the proposals put forward by Mr. Bernard Baruch for the international control of atomic energy, and hopes to see their early implementation."

In the short discussion which followed the feeling was expressed that in general the U.S. proposals were in full conformity with the Lilienthal Report on the International Control of Atomic Energy; a report which already has the approbation of the Atomic Scientists Association. An amendment to defer action on the motion was defeated and the resolution was carried by a big majority.

Finally arrangements were discussed for the holding of an International Conference at Oxford from July 29 to 31.

Empire Scientific Conference

The Royal Society's Empire Scientific Conference opened in London on June 17. The King and Queen were present.

No worthwhile survey of the conference could be prepared until the conclusion of the conference, but it is hoped to publish a report in the August issue.

Talking with the Gullet

The process (discussed by the *Lancet*: March 2, 1946, p. 312), whereby people from whom the larynx must be removed are taught to speak with their gullets, is a remarkable achievement both of education and of the powers of adaptation of the human body. Removal of the larynx is a serious operation which used to be followed by sepsis which was difficult to control. The use of penicillin and sulphonamides have reduced this sepsis, but the dreadful prospect of loss of the power of speech remains. Now we know that it is possible to alleviate even this serious result of the operation, for astonishing progress has been made in the education of people to speak with their gullets. They learn to speak, if a good, old-fashioned term may be allowed, by means of a suitably modified belch.

First the patient must learn to swallow air. It is best that this should be learnt before the removal of the larynx, but this is not essential. The patient is taught to close the opening between the vocal cords (glottis) and also the lips and then to expand the chest as he swallows. Air is thus aspirated and this can be again brought up as a noisy belch. When the operation wound has healed, the swallow-

ing of air and belching are resumed. The 'trick' can be learned more readily if the patient sucks a boiled sweet or takes alkaline powders which react with the acid of the gastric juice to make gas in that organ; but it is better to go without these aids. Before long the patient learns to convert the belches into a *sh* and *ch*. Then vowels are added, to make words like *church* and *scrub*. Later explosive consonants such as *p*, *d*, and *k* are learnt, so that other words can be made spoken. The patient's problem then is to speak either one long word or several syllables with each intake of air. Thereafter attempts are made at short sentences. Because the patients have to pause to take in air, the grouping of words may be abnormal and this appears to be a difficulty which is not easily overcome.

Attempts have been made to find out how this remarkable achievement of talking with the gullet is done. If the patient swallows a thick barium paste, this adheres to the walls of the gullet and pharynx, so that the movements of these parts of the body can be studied by means of X-rays. Observations show that the gullet is usually the reservoir of air, although one patient used the stomach also for this purpose. The opening between the vocal cords through which air passes to make normal voice sounds is replaced in these patients by a narrow channel in upper parts of the gullet or, sometimes, in the lowermost part of the pharynx. It has been found possible to take photographs of gullet speech by asking the patient to speak into a microphone connected to a cathode-ray oscillograph. These photographs show that the substitute for the glottis in the gullet vibrates very irregularly and this explains why the 'gullet voice' is husky and indefinite in pitch. A few patients have, however, learned to modulate their gullet voices through a few tones or even through an octave. Patients who have made good progress in gullet speech teach others who are learning and thus perform a very useful service. The success achieved can also be demonstrated by means of gramophone records to those who have to undergo the loss of the larynx. These gramophone records were heard at a meeting of the Physiological Society recently.

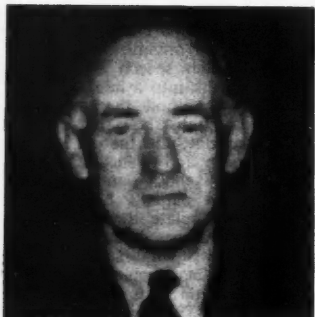
Beekeepers' Research Committee

THE British Beekeepers' Association has established a Research Committee whose primary function is to co-ordinate research activities. It seeks also the establishment of a clearing house for information and the results of contemporary research.

In a letter to the Editor, the Chairman of the Research Committee, Mr. E. B. Wedmore (whose address is: Totease House, Buxted, Sussex) makes the following the appeal for co-operation:

"The object of bee-keeping is commonly regarded as the production of honey, but the national interest is even better served by the pollinating activities of the foragers,

a service which has been reliably valued in this country at £4,000,000 per annum. At the same time, the craft affords a fascinating hobby for many thousands of amateurs whose activities, being spread throughout the country, are of greater national importance for the reason indicated, than are those of the commercial honey producers. The amateur finds not merely a hobby which may be turned to profit, but a never ending interest in entomology, biology, botany, meteorology, agriculture, horticulture, handicrafts, and an endless argument with his fellows about methods of management and the errors of tradition and of pseudo-science. It is for the removal of these latter errors that co-operative research is so important. Co-operation is essential because there are so many variables that the individual can seldom conduct an experiment on an adequate scale and is too frequently deceived by an element of chance. Most that is known in the craft has been the result of the enthusiasm of independent and generally unpaid observers, so the Committee is very much alive to the importance of amateur observers and is seeking to contact them, not only those in the ranks of members of Bee-keepers' Associations, but also the unattached. We are seeking and hope to hear also from those concerned in researches in other fields which are of interest to beekeepers, with a view of affording assistance and organising co-operation to mutual advantage."



Sir Jack Drummond has resigned the post of scientific adviser to the Ministry of Food to become research director of Boots Pure Drug Co.

The Imperial Institute Reopens

THE Exhibition Galleries of the Imperial Institute at South Kensington are again open to the general public from 10 a.m. till 4.30 p.m. on weekdays. There is a display of Empire films in the Institute's cinema each day at 3.30 p.m.

French Scientific Films

MEMBERS of the Institut Français and others saw something of the French contribution to scientific films when M. Jean Painlevé addressed them recently and showed some of his work. Dr. Julian Huxley, introducing M. Painlevé, described him as a master of the popular scientific film. M. Painlevé stressed the

part which the film could play in research by virtue of its power to expand or contract time scales enormously and to isolate and preserve records of rare or transient scientific phenomena. Three of M. Painlevé's films were shown: *Hippocampe* (Sea Horse), a beautifully photographed underwater account of this creature's life cycle; *Solutions Françaises*, a well intentioned documentary of France's achievements in pure and applied science; *Vampire*, a 'horrific' but extremely interesting description of this blood-sucking species of bat found in South America.

Centenary of Anaesthesia

THIS year sees the centenary of the introduction by W. T. G. Morton of anaesthesia for surgical operations. The *British Medical Bulletin* celebrates the centenary by devoting its latest number (Vol. 4, No. 2, 1946) to the subject of anaesthesia and analgesia. There is an interesting historical section, while articles describing recent advances in this field deal with such subjects as "The Search for Morphine Substitutes", "Synthetic Substitutes for Atropine", "Trichlorethylene as an Anaesthetic Agent" as well as subjects of exclusively medical interest.

Industrial Spectroscopy

AN Industrial Spectroscopic Group has been formed under the auspices of the Institute of Physics. Mr. F. Twyman, F.R.S., is chairman of the Group and Mr. E. H. S. Van Someren honorary secretary. Members of the Committee are: Lt.-Cmdr. J. Convey, Mr. B. S. Cooper, Prof. H. Dingle, Dr. A. G. Quarrell, Mr. E. W. H. Selwyn, Mr. D. M. Smith, Dr. S. D. Steele, and Mr. A. Walsh. Further particulars may be obtained from The Secretary, Institute of Physics, 19 Albemarle Street, W.1.

25 Years of Insulin

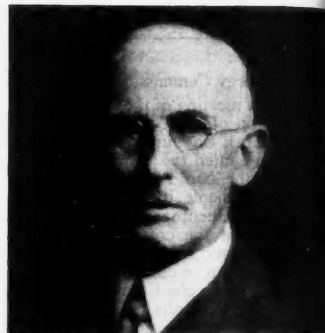
THE silver jubilee of the discovery of insulin falls this year. At the Royal Institution on July 5 the event was commemorated by a meeting addressed by Professor C. H. Best, co-discoverer with Banting of this hormone.

Conservation of Scottish Wild-life

A COMMITTEE of experts has been set up at the request of the Scottish National Parks Committee to advise 'as to the steps which it is desirable and practicable to take to conserve wild life in Scotland'. Members of the committee are: Professor James Ritchie of Edinburgh University (Chairman), Dr. John Berry, Dr. F. Fraser Darling, Dr. Murray Macgregor, Professor J. R. Matthews and Sir J. Douglas Ramsay. This Scottish Wild-life Conservation Committee will cover botany, zoology and geology. Their first task will be to collect and tabulate information about suitable conservation areas.

Science and Human Welfare

THE proceedings of the recent conference on Science and Human Welfare (reported in our March issue) have now been published as a book. This is obtainable



Dr. C. C. Paterson, director of the G.E.C. Research Laboratories, who received a knighthood in the Birthday Honours List.

through booksellers at half a crown; or direct from The Temple Fortune Press, 6 Herbal Hill, London, E.C.1, price 2s. 8d. post free.

Death of J. L. Baird

THE death occurred on June 14 of J. L. Baird, the television pioneer, at the age of 58.

Henry Wickham's Centenary

THIS year's centenary of Wickham's birth is an occasion to be celebrated by all interested in rubber. It is not merely Wickham the explorer, who for 50 years wandered through Central Africa, Australia, New Guinea and the Pacific isles, that one thinks of on this occasion; and certainly not the inspector of forests in India or the police inspector of Honduras. But it is the planter who outwitted the authorities in Brazil just 70 years ago, when he brought Hevea seeds from the Amazon rubber country in which he was resident at the time. Fiction is indeed rivalled in the way in which he chartered an ocean-going steamer which was trading to the Amazon and had been abandoned by supercargoes without a return freight; in which he set all hands to collect seed, and got 70,000 of them passed by port authorities as botanical specimens! While it is true that back at Kew less than 4% of these germinated, the India Office who paid his expenses were nevertheless well repaid after Ceylon had been chosen as tropical nursery.

Radar Monographs in Preparation

CAMBRIDGE University Press announces a new series of monographs dealing with the advances in radio techniques made during wartime. All the monographs will be by authors who were personally responsible for important advances in the subjects they write about. Mr. J. A. Ratcliffe is the general editor. Nine such books are now in active preparation; of which two, *Radio Navigation Devices* by Dr. R. A. Smith and *Velocity Modulated Electron Tubes* by Mr. A. H. Beck are complete and will go into production immediately.

A series of new monographs on nuclear physics is also being prepared, under the general editorship of Professor N. Feather.



...or of the G.E.C.
received a knight-
honours List.

...alf a crown; or
Fortune Press,
C.I., price 2s. 8d.

...une 14 of J. L.
...eer, at the age

...ary
Wickham's birth
celebrated by all
is not merely
who for 50 years
al Africa, Aus-
the Pacific isles,
s occasion; and
or of forests in
or of Honduras.
o outwitted the
70 years ago,
seeds from the
n which he was
ction is indeed
ch he chartered
or which was
and had been
goes without a
he set all hands
70,000 of them
es as botanical
ue that back at
ese germinated,
id his expenses
aid after Ceylon
al nursery.

Preparation

...ess announces a
dealing with the
ues made during
raphs will be by
ally responsible
in the subjects
A. Ratcliffe is
such books are
; of which two,
by Dr. R. A.
tulated Electron
k are complete
on immediately.
aphs on nuclear
ared, under the
essor N. Feather.